BULLETIN

OF

THE INSTITUTE OF PHYSICS

AND

THE PHYSICAL SOCIETY

VOLUME 12 . NUMBER 11 . NOVEMBER, 1961

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Vol. 12, No. 11 NOVEMBER, 1961

Errors in Textbooks and the Tradition of Physics Teaching

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INTRODUCTION

THE writer has long been seriously concerned about the very poor grasp of physics shown by students embarking on courses of higher education in science and engineering. Very intelligent students who have obtained high marks in the G.C.E., and who have memorized great numbers of facts, show very little knowledge, and less understanding, of basic principles.(1)

As part of an investigation into the causes of this serious situation I recently worked rapidly through a dozen textbooks, making notes of the more obvious errors. As I have not used any books of this kind for several years I was surprised and appalled by the number and seriousness of the errors. The books were mostly written for G.C.E. " A Level " and scholarship courses, but a few were intended for O.N.C. They include several of those which are most extensively used in sixth forms, and are thought to represent fairly accurately the present tradition of physics teaching at this level in Britain. In most cases the books were recent editions or reprints of works first published some years ago, so that there has been ample opportunity for revision. A few were recent publications.

It is not possible to state or discuss more than a small fraction of the errors observed. A number of typical examples are given below, and some points which seem to be of particular interest are discussed briefly. No attempt has been made to assess the relative importance of different mistakes. Some are quite trivial, whereas experience in lecturing and examining has shown me that the acceptance of some of these mistaken ideas makes it almost impossible for a student to understand later developments in the subject without thorough re-education.

THERMODYNAMICS

An essential foundation of this subject is the concept of an equilibrium state. This is not explicitly discussed by any of the books examined. One author even uses the same term (" dynamic equilibrium ") to describe both systems in thermodynamic equilibrium and also steady states of systems which are not in equilibrium. There are therefore several seriously incorrect and misleading " definitions " such as " a saturated vapour is one which is in contact with its liquid in a closed space ".

Several books omit altogether any consideration of the thermodynamic concept of reversibility, even when discussing such processes as isothermal and adiabatic expansions. It is rarely explained, as it should be, that such formulae as PV^{γ} = constant, apply to ideal circumstances and cannot apply exactly in any real situation. One textbook on heat very misleadingly uses the word " reversible " with its vulgar meaning. Where the concept of reversibility is discussed it is usually done very obscurely, and the same authors later make errors which can be attributed to failure to understand this principle.

Entropy changes are defined in various cases without any reference to reversibility or to the fact that entropy is a function of state.

As a result of the neglect of basic principles the treatment becomes more inaccurate as the subject is taken to a higher standard. Consider the following:

" When a quantity of heat δQ flows from a body at temperature T_1 to a body at temperature T_2, it can be imagined that this takes place in a series of infinitesimally small reversible stages, so that we can speak of the action as being reversible, or we can imagine the transfer to take place with the aid of a reversible heat engine. The loss of entropy of the hot body at T_1 is $\delta Q/T_1$ and the gain in entropy of the cold body at T_2 is $\delta Q/T_2$ and the gain in entropy of the whole system is $\delta Q(1/T_2 - 1/T_1)$. This is true also of irreversible processes—in fact, the intermediate steps or the mechanism of the action have no effect on the value of the change of entropy ".

Now if heat is transferred reversibly, as in an ideal heat engine, some heat $[= \delta Q(1 - T_2/T_1)]$ must be converted into external work, and the entropy change is zero. If heat is transferred by a process such as conduction this cannot possibly be represented by a series of reversible stages, since the system is not in equilibrium. Then there will be an increase of entropy as given above. Other irreversible processes involving some external

work will give intermediate values of entropy increase. The conclusion of the paragraph quoted is thus quite false. It would be difficult to imagine a more fantastic example of confusion, but this appears in a book of deservedly high repute, and has remained unchallenged for sixteen years. Unfortunately, if a student were to be taught from the best of the textbooks examined it is unlikely that he would appreciate the glaring errors in this passage.

Most of the authors believe implicitly in equipartition of energy. Hence we read such ridiculous statements as this: " The values of gamma for monatomic, diatomic and triatomic gases are 1·66, 1·41 and 1·29 respectively. If gamma is not equal to one of these values it proves that the gas under examination contains molecules having a number of atoms in them different from the number normally present ".

One author who is aware that equipartition is not always true, wrongly assumes that it must be so when Maxwell-Boltzmann statistics apply.

The whole subject seems far too difficult for treatment at this level.

IDEAL GASES

There is considerable confusion in all the books on heat between the experimental law relating volume to temperature for real gases (Charles, Gay-Lussac) and the definition of the ideal gas temperature scale. The account given is as follows. The specific volume of a gas (at constant pressure) is determined at various temperatures measured on the mercury-in-glass scale. A graph of V against T is extrapolated back to $V=0$, which is said to be at absolute zero.

Now the law has been extrapolated into a region where the gas will have condensed, and where the temperature scale has not yet been defined. It seems most improper to teach students to carry out such a meaningless " extrapolation ", where a graph is drawn to relate something which does not happen, to something which does not exist. Our authors next *define* an ideal gas as one which obeys the laws of Boyle and *Charles*. This, of course, makes the properties of an ideal gas depend on those of mercury.

There is further confusion. For example:

" An ideal gas is defined as a gas which obeys the laws of Boyle and Charles and for which there is no force of attraction between neighbouring molecules. This last part of the above statement signifies that the energy of the molecules is entirely kinetic and depends only on the temperature of the gas".

Now if Boyle's law is obeyed under all conditions kinetic theory shows that there can be no forces of attraction or repulsion between molecules. This does *not* mean that the energy of the molecules is entirely kinetic. In fact all molecules have internal energy which is partly potential. (Amazingly enough many of the books teach that heat is always kinetic energy, even when referring to lattice vibrations).

To clarify this situation we note that an ideal gas is correctly defined as one which obeys Boyle's law under all conditions. (It is sometimes helpful at certain stages to add the requirement that the internal energy is a function of temperature only, although this can later be shown to be a necessary consequence of assuming Boyle's law). The equation PV = RT for an ideal gas is not a law, but the *definition* of the temperature T. Now it is *essential* to show that all ideal gases must define exactly the same temperature scale. This cannot be done by extrapolation from experiments on real gases, since these are limited to known materials. The thermodynamic proof was given by Kelvin and is well known. I consider that this is too difficult even for scholarship pupils. (But some of the books give it, without explaining its significance). However, we can and should teach that there *is* such a proof.

Our authors and various examining bodies expect students to derive the ideal gas equation assuming the laws of Boyle and Charles. Now it should be clear that one cannot " derive " a definition. Further, it must give students a very odd idea of the intellectual capacity of the physicists of the two generations between Charles and Kelvin, if they suppose that the equation can be established by elementary algebra.

MECHANICS

Very few of the authors appear to understand the significance of Newton's laws of motion. This is shown by such incorrect definitions as:

" Dynamics deals with bodies which are in motion relative to their surroundings; statics concerns bodies at rest ".

Following this line of thought one author describes a body in S.H.M. as being in equilibrium at the point of maximum displacement when it is instantaneously at rest, but when of course the *acceleration* is a maximum ! In problems of circular motion in nearly every book centrifugal force is correctly stated to act *on the restraining system*, but then force diagrams are printed showing it acting *on the accelerated body*, which is apparently supposed (and sometimes stated) to be in equilibrium. The concepts of dynamics so created in the students' minds must be utterly chaotic.

A consequence of this misunderstanding of first principles is the completely fantastic treatment of intermolecular forces in all the textbooks on heat and mechanics. All the authors are aware of the attractive part of the Van der Waals force and know that it falls off rapidly with distance. (One author assumes an inverse-square law, in confused association with the a/V^2 term in the equation of state). However, the short-ranged repulsive forces are unknown. Hence we meet several statements " explaining " surface tension such as these typical examples:

" A molecule well inside the liquid will be pulled equally in all directions by the other molecules. Another, in the surface, will have an unbalanced force pulling it downwards at right angles to the surface ".

And: " When, however, a molecule is at the surface of the liquid it will not be attracted equally in all directions, for there is no liquid above it. In consequence of this such molecules will tend to move towards the interior of the liquid ".

This model is assumed both for solids and liquids in every case. A moment's thought shows that it is unstable and absurd. If a molecule in the interior of a body were to be displaced slightly from the point exactly half way between two neighbours it would be attracted more strongly to the *nearer* one, causing a complete collapse of the body. (A simple calculation shows that indeter-

minancy does not affect this problem in the way it does that of atomic structure). Further, it is obviously beyond reason to suppose that the outermost molecules of all bodies are accelerating inwards.

How can anyone entertain such a fantastic conception of matter as is presented in these quotations ? I believe that the phrase " tend to move " gives a clue. Critics are often accused of " quibbling " when they draw attention to clumsy wording. In every case which I have investigated by personal discussion I have found that such misleading phrases originate in a failure to understand the principles concerned, and of course they make it harder for the student. Unfortunately, despite Galileo and Newton, most people still think that a force causes a body to " tend to move ".

Another similar case of muddled thinking is shown by the use in several of the books of such misleading phrases as " conversion of matter into energy ". This gives a false idea of the meaning of the mass-energy relationship. It is important to appreciate that this relationship was introduced to *preserve* the law of conservation of mass.

ATOMIC PHYSICS

Most of the descriptions of radioactivity give the impression that *all* radioactive substances emit α, β *and* γ-rays. There is no account of positron emission, but one work devotes a paragraph to proton radioactivity ! None of the books gives a correct indication of the energies or ranges of the nuclear radiations. Instead there are many misleading statements, of which the following are typical.

" γ-rays have wavelengths about 100 times less than those from an X-ray bulb."

" α-rays are completely absorbed by an aluminium plate 5mm thick." (How true !)

" β-particles can pass through aluminium 1 cm. thick."

" The α-rays are responsible for about 99% of the energy."

There is almost no attempt in these books to give a simple indication of the types of atoms which exhibit radioactivity, or how active materials occur in nature or are produced in the laboratory. Generally the chapters on atomic physics are unsystematic collections of details which contain various errors. For example, we are told that the energy liberated in fission is in the form of radiation, γ-rays are produced by the stopping of β-rays, scintillation counting is obsolete, cosmic rays are electromagnetic radiations, electrons are *certainly* not waves and α-rays have only a weak photographic effect. Muons are confused with π-mesons, and we are told that the electron diffraction patterns found by Davisson and Germer were *exactly the same* as would have been given by X-rays. The *absorption* and the *moderation* of neutrons are confused.

I view with some alarm proposals to increase the amount of atomic physics taught in schools.

OPTICS

The optics in these books consists mostly of geometry and " u and v " calculations. One would not expect to find many errors of fact in this, but in any case I lack the dedication to try. However, I noticed some seriously inaccurate ray diagrams of spectrometers and eyepieces. The latter were very badly done, the whole principle of the design being obscured.

Although there is a great amount of mathematical detail there is very little discussion of basic principles in optics. Thus with a few exceptions the books give practically no account of visual acuity or depth of focus. Hence they do not even explain what we understand by a clear image. The type of optics taught would be of little use in practical applications such as photography.

Various treatments of the pin-hole camera teach that the image becomes more and more well-defined as the hole is made smaller, even although the same books later give accounts of diffraction.

The subject of spectra receives disproportionately brief treatment and remarkably little illustration. The origins of spectra are generally dismissed in such terms as

" Continuous spectra are formed by light from incandescent solids. Line spectra are due to gases".

On this basis any student who has ever seen a rainbow must conclude that the sun is solid.

ELECTRICITY

There are some incorrect electric circuit diagrams, and uncounted breaches of convention, particularly the use of straight lines or the inductance symbol to represent resistance. It is not generally appreciated that low value resistors such as shunts require four terminals.

Permittivity, permeability and related quantities are often treated as constants.

There is serious confusion over systems of electrical units. There are of course two distinct types of c.g.s. system. In one approach permeability and permittivity are defined to be numbers and consequently physical quantities have different dimensions according to whether they are measured magnetically or electrostatically. The quotients of the e.m.u. and e.s.u. then involve the velocity of light. In the other approach permeability and permittivity are defined to have dimensions such that other physical quantities have the same dimensions whether measured magnetically or electrostatically. In this case the quotients of the e.m.u. and e.s.u. are pure numbers. Unfortunately none of the textbooks distinguishes these two approaches, and the various ideas are sometimes introduced muddled together. (This confusion is often found in more advanced books).

Some authors give the magnetic force on a conductor or moving charge in terms of the magnetic field intensity, whereas it does in fact depend on induction (flux density). This is important when a change to another system of units is required.

One of the books states in one chapter that electrical conductivity of metals tends to zero at low temperatures, and in another chapter it states that the resistivity tends to zero. (Both statements are false).

A number of books use the misleading, futile and illogical " unit cube " definition of resistivity.

None of the authors of these textbooks appears to be clear as to the distinction between a *definition* and a *law of nature*. This is shown in the discussion of such quantities as viscosity, specific heat, thermal conductivity and electrical resistance. In the latter case every book first states Ohm's law, and then defines resistance. It is either implied or explicitly stated that the definition depends on the law. This is equivalent to making the

definition of velocity depend upon the non-existence of acceleration. This approach leads the authors into logical tangles when they describe cases where resistance varies with temperature, or where the analogous " magnetic circuit " is introduced.

The rule for adding resistance in series is wrongly said to depend upon Ohm's law.

The experimental proofs given for Ohm's law nearly all depend upon the measurement of current and potential difference by meters. It is appreciated that the calibration of these meters must not depend upon the law. Thus it is universally asserted that we therefore cannot use a moving-coil voltmeter, so an electrostatic meter is recommended. Now this is pointless, since all precise voltmeters (including electrostatic ones) must be calibrated against the potentiometer, which is an instrument whose function does *not* depend on Ohm's law. In several cases it is assumed that an ammeter *can* be used in the proof experiment. Such meters, however, are calibrated by measuring with a potentiometer the potential difference across resistors in series with them, and applying Ohm's law to these resistors.

Since null methods give far greater accuracy than does the use of meters it is obviously desirable to describe a null method of proof. This is not done by any of the textbooks examined.

HEAT TRANSFER

The definition of thermal conductivity in every case is made to depend upon a heat-flow law which is not always true, and the confusing " unit-cube " idea is often used. Several authors incorrectly limit the definition to steady-state conditions. Quantitative considerations, if discussed at all, are very inaccurately given. One example of many is: " Experiments show that a good conductor of heat is also a good conductor of electricity ".

Several textbooks give detailed " solutions " to the problem of the growth of ice on a pond. It is always assumed that the temperature of the ice surface is the same as the bulk air temperature. This is of course quite incorrect. There will be a step in temperature in the surface layer of air which will be a function of heat flow and of wind speed, and because of radiation, will even be affected by cloud. Hence all these analyses are incorrect. When this problem is set in examinations it is clear from the data given that the examiners expect this incorrect analysis. The question has been set by school examination boards and by The Institute of Physics in the Graduateship examination. Questions involving fluid flow in pipes, which require similar errors in their " solution " have been set by the same bodies. There are a number of descriptions of the popular method for measuring the conductivity of soda-glass in the form of a thin-walled tube. This requires the invalid assumptions that one surface is at the same temperature as the bulk of the cooling water, and the other is at the same temperature as the steam which is condensing on it.

MISCELLANEOUS

(Only a few typical examples can be given).

Physical properties of materials which are functions of temperature often have values quoted without the temperature of measurement being given. In many cases it is implied that such quantities are constants, and in some they are explicitly defined to be so. (This applies especially to specific heats).

The ranges of temperature over which various types of thermomenter can be used are given very inaccurate values in several cases.

The distinction between sliding and rolling friction is rarely made. Thus we meet a cylinder rolling down a " smooth " slope.

The value of the gravitational acceleration is wrongly stated to be a maximum at the surface of the earth.

The impression is often given that there is no difference between C_p and C_v for liquids and solids.

The normal presence of free electrons in a semiconductor is wrongly attributed to a process analogous to the cascade production of electrons in a gas discharge.

In one case atomic weights are referred to hydrogen as standard with atomic weight unity.

We are informed that:

" Viscosity decreases as temperature increases for every fluid ".

"Apart from mercury liquids are bad conductors of heat".

" The energy of a gas is directly proportional to its absolute temperature".

Mathematical errors include a number of serious mistakes in signs, especially in differentiation. Errors arise particularly where there are functions of more than one independent variable, as with valve characteristics. Thus two books give the equation

$$\frac{\delta V_a}{\delta V_g} = \frac{\delta V_a}{\delta i_a} \times \frac{\delta i_a}{\delta V_g}$$

Here δi_a has been " cancelled " despite the fact that different variables are being held constant in each case. This treatment, together with some cases of the use of the notation for ordinary differentiation in problems which really involve partials, must cause considerable confusion to a student who is only just beginning to learn calculus.

GENERAL IMPRESSIONS

On reading most of the textbooks the thing which impressed me most strongly was the enormous amount of information presented. No doubt some authors give far more material than is strictly required by the examination syllabus, and many of the more advanced ideas are only needed for a minority of scholarship candidates, but even so the demands made upon the student seem grossly excessive. After all, physics is only one of the subjects which he is studying. The material is not only quantitatively excessive. Many of the ideas involved are extremely difficult—a fact which is well illustrated by the errors in the books. It seems to me impossible for anyone but a genius to acquire a reasonable understanding of such a complex subject, treated so widely, in a sixth-form course. In consequence success in examinations must depend far too much on parrot-like memorization, and it is easy to understand why students have so little appreciation of fundamentals. If we remember that in a few years a student may become a teacher, an author or an examiner, we may appreciate how the present situation has arisen.

I consider that it is essential that syllabuses should be greatly reduced. Many of the less vital topics could be omitted altogether, while some of the more difficult ones

should be left to the university. There are some very difficult subjects, such as dynamics, which are vital, and must be taught at as early a stage as possible. Far more time and care must be devoted to these, whatever else may have to be sacrificed.

THE TRADITION

No man can be an expert in more than a very limited field, but one may be expected to teach or examine any part of one's subject. This is only made possible by reliance upon tradition. There is in all subjects a highly complex tradition, embodied in textbooks, syllabuses, examination papers and lecture notes. Normally any teacher, author or examiner accepts this in all aspects of his subject except those in which he has research experience or other expert knowledge. In his own speciality he will make his own small contribution to the growth of the tradition.

The authority attributed to tradition in physics is almost unbelievable. I have long known many examples of this, and have received startling evidence since beginning to criticize the textbooks. It is not only that people do not believe the criticisms. Many persons are literally incapable of conceiving that the tradition can be seriously wrong, so that they do not realize that such a proposition is being made. Instead they automatically twist the criticism in their minds into an allegation that the textbooks are " out-of-date ". I wish to make it quite clear that this is not my principal complaint so far as sixth-form textbooks are concerned, although it certainly does apply to many books written for university courses. My complaint is that the books are grossly inaccurate and fail lamentably to teach the fundamentals of the subject.

The writer by checking such facts as he is able and by subjecting other points to logical analysis, has uncovered many errors. Physicists with different interests and specialist knowledge could obviously reveal many others, and thereby show an even blacker picture.

It is very important to note that many of the most serious and misleading mistakes have remained unchallenged over several years. Any reader who has noticed them has lacked sufficient public spirit to take the trouble to write to the publishers for the benefit of less well-informed readers. The Ministry of Education and the Institute of Physics have failed to take any action. Further, we have seen in several cases that the examination boards accept the same mistaken ideas. There is something very wrong indeed here.

Serious errors of principle arise even in the examination papers for degrees and similar awards.[2] *The British tradition of physics education is radically unsound.*

All educational planning is based on the assumption that the tradition is essentially reliable. Hence money and effort are diverted to side-issues which, however desirable in themselves, can only be regarded as luxuries in present circumstances.

CONCLUSIONS

A radical reform of physics education is urgently required. Although reduction of excess material is vital, little else will be achieved just by introducing new syllabuses, since the same ideas will inevitably be taught. What is required is a critical attitude, in which each individual tries to correct such parts of the tradition as he can. Educational thinking, which is at present almost exclusively concerned with *methods* must be directed more towards *content*. Above all, it must be recognized that the sound teaching of physics is vitally important and most exceptionally difficult, and hence demands the ablest minds available.

REFERENCES

1. *Bulletin of The Institute of Physics*, Vol. 12, No. 3, p. 75. (1961).
2. " University Examinations and College Physics Teaching ", *Technical Education*, Vol. 1, No. 9, p. 23. (1959).

Appeal for the Physics Trust Fund

Donations or subscriptions were received from the following members between August 23 and October 23, 1961:

Mr. M. L. Ellis	Mr. B. McCarthy	Mr. W. J. O. Scott
Mr. F. W. K. Firk	Mr. D. McGill	Prof. R. W. Snell
Dr. D. W. Gillings	Dr. Helen D. Megaw	Dr. R. Stratton
Mr. R. J. Hodgkinson	Dr. M. O. Pelton	Dr. E. J. Whitmore

The A.S.T.M. X-ray Powder Data File Fund Sub-Committee of the X-ray Analysis Group has agreed to transfer £5,000 from its Fund to the Physics Trust Fund.

The total received in donations or promises (including tax recoverable on covenanted subscriptions) was on October 23, £118,141.

Bulletin of The Institute of Physics and The Physical Society

New Plastic Materials

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M.A., D.Phil.
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[A paper given to a symposium on new materials held by the London and Home Counties Branch on November 25th, 1960]

THIS paper must, of necessity, be something of a catalogue, and first some of the properties which have contributed to the rapid growth of the plastics industry will be reviewed. From this base, new trends in materials and applications will be considered.

There has been a very large increase in the volume of plastics production over the past ten years, and this high growth rate continues. The fact that the volume of synthetic plastics production is some 10-20% of that of steel and about 10 times greater than that of copper

TABLE 1

Ultimate Tensile Strength dynes/cm²			*Young's Modulus dynes/cm²*	
10^{11}			10^{13}	
			Tungsten	
			Iron	
Tungsten			Copper	
Drawn bronze	10^{10}		Gold. Diamond	10^{12}
		Polypropylene	Glass	
Steel		Fibres "Terylene"	Tin	
		Nylon		
Brass				
Wood			Lead	
Gold	10^{9}	"Perspex". "Delrin"		10^{11} Filled P.F.
		Nylon. Polycarbonates		
Cast aluminium		P.V.C. P.F.		
		Polypropylene		"Melinex"
Porcelain		Flexible P.V.C.		P.V.C.
		Polyethylenes		"Perspex"
Lead		P.T.F.E.		Nylon
	10^{8}			10^{10} Polypropylene
Porphyry		Non-reinforced rubbers		
				Polyethylenes
	10^{7}			10^{9}
				10^{8} Rubbers
				10^{7}

puts this industry into perspective. This comparison is not meant to imply that polymers are interchangeable with metals, although in fact in many applications metals have been replaced by plastics. Factors influencing this replacement are durability (lack of corrosion, etc.), aesthetics and economics. Well-known examples where polythene is now frequently preferred to metals are housewares and toys.

Generalizing their properties, plastics are less rigid (have lower elastic moduli) than metals and " stones " (porcelain, concrete, glass, etc.), but are more comparable with these conventional products in strength. This is shown in Table I.

Plastics are thermal and electrical insulators, but, unlike the " stones ", also insulators, are not necessarily brittle. Polymers may be obtained transparent or translucent, and on this account may be self-coloured. Compared with both metals and " stones ", their densities are low: a polymer of increasing importance, polypropylene, for example, has a density of 0·90 g/cc. Thus on their properties alone, plastics must be considered as a class of materials in their own right, and the very low densities contribute to their low volume cost compared with metals (Table 2).

The rapid growth of the industry has enabled the cost of the materials to be held steady or frequently reduced during the past five years. whilst the general cost of living has increased steadily. Thus polythene and poly(vinyl chloride), costing 38d/lb and 21d/lb respectively in 1955, are now available at 22d/lb and 16d/lb. One further property contributing to the rapid growth of the plastics industry is the very easy and cheap fabrication into articles which can be made reproducibly with fine tolerances.

After this introduction, it is perhaps expedient to consider some examples in which polymers have become established, and to examine the reasons for their success. The new G.P.O. telephone handset is moulded in " Diakon " (poly(methyl methacrylate)). Here the properties of easy moulding to a fine tolerance product of high gloss, capable of being self-coloured, are used. Good rigidity and strength and comparatively high scratch resistance are features of this polymer, and some of these properties are again important in applications of " Perspex ", the sheet form of poly(methyl methacrylate), such as baths and toilet basins.

Polythene has had a remarkable growth, and one project which would not have been possible without it is the Transatlantic Telephone Cable. At least two basic designs of cable have been, or are being, used; the original heavy pattern, and, more recently, a lighter version. Here the qualities demanded which could be met by polythene, but could not be matched by rubber or gutta-percha, are very low and consistent loss properties, durability and lack of corrosion of the copper conductors, and the ability to be fabricated into these modern cable designs. The good insulating properties of polythene can also be used in power cables. Further examples of moderately well-established polymers are nylon 66, which apart from its use in fibres, has found considerable use in gears (in virtue of its low abrasion loss, no lubrication, and easy moulding to the fine tolerances demanded), and poly (vinyl chloride), PVC, which finds a multitude of uses from photographic sink units in rigid PVC to wire insulation in plasticised grades. In the latter application, resistance to oil and the ability to be self-coloured are obvious attributes. Packaging is another field which has grown explosively, and this increase has been based primarily on polythene.

Thus, the plastics stage is set, and it is on this basis of established polymers and applications that new materials and new applications must be considered. New materials can be of interest for two reasons, either technical or economic advantages: perhaps only the former should be the concern of this paper, but the price factor can never be ignored. Technical deficiencies in the well-known polymers can include low softening temperature, low rigidity, brittleness, low strength (for example, to tearing) and comparatively difficult fabrication. Some of these deficiencies have been met over the past 10 years by modifying the polymers, sometimes in a minor fashion and at other times in a major way, as, for example, with the high density polythenes prepared by several polymerisation processes different to that used for the original material. Here development still continues, and some of the more important high density polythenes are in fact ethylene-butene copolymers, which materials overcome some of the brittleness of the straight high density polythenes. Considerable progress has been made, however, with entirely new polymers, and it is these with which this paper is primarily concerned. First, products well established in production (although on a comparatively small scale) will be discussed, followed by a consideration of some newer polymers.

" Fluon " polytetrafluoroethylene is characterized by

TABLE 2

Plastics and Other Materials — Comparison of Volume Costs

Material	*Cost* £/*ton*	*Density* lb/*cubic inch*	*Cost* d/*cubic inch*
Polythene	205	0·03	0·6
PVC	168–280	0·04–0·05	0·7–1·2
Nylon 66	792	0·04	3·4
Brass	200	0·30	6·4
Steel (billets)	40	0·28	1·2
Copper	226	0·32	7·8
Lead	68	0·41	3·0
Aluminium	182	0·10	2·0
Raw Rubber	~224	0·03	~0·7

resistance to high temperatures, more or less complete chemical inertness, and low friction and, on the basis of these properties, is used in gaskets and seals for chemical plant, in the electrical industry, and (as an application of its low frictional properties) in covering bakers' rollers. A severe limitation of the use of this polymer (apart from its price) is set by its difficult processing. This, however, has recently been overcome to some extent by copolymerizing tetrafluoroethylene with hexafluoropropene, and by making modifications to the homopolymer itself.

Poly(ethylene terephthalate) is well known in fibre form as " Terylene ", a versatile synthetic fibre. Less well known perhaps is the biaxially oriented film made from this polymer which combines high strength and toughness with transparency and good electrical properties. These properties have led to its use in capacitors, recording tape, lapping cables, display packaging, etc.

Polypropylene is a polymer with a bright future. A member of the polyolefines family, this stereoregular material has the distinction of a very low density, which, coupled with high rigidity and strength and a high softening temperature compared with polythene, suggests its use in a number of applications, such as domestic ware ranging from linen baskets to tea-ware, toys, and as a tough, transparent film with a variety of uses.

Another material with interesting properties and potentialities is polyoxymethylene (polyformaldehyde), which has high stiffness and strength, high softening temperature and low water absorption. It is difficult to forecast where this material will fit into the plastics scene, but its use in car components appears to be very probable.

Nylon 6 is a material comparatively new to this country, and potentially cheaper than the more usual nylon 66. Nylon properties are retained in this polymer, which is, however, somewhat easier to fabricate, and a more widespread use of nylons in applications other than fibres seems very likely.

A comparatively expensive polymer, which, however, finds some applications because of its chemical inertness and high form stability, is that derived from bis(chloromethyl) oxacyclobutane, having a repeat unit

$$CH_2 . C(CH_2Cl)_2 . CH_2 . O$$

This polymer is finding some use in aircraft components.

Remarkable properties are shown by a new class of polyesters, the polycarbonates. These transparent plastics have extremely high impact resistance: a polycarbonate nail can be driven into a block of wood. At present their exploitation is retarded by a comparatively high price and by indifferent solvent resistance.

A new plastic film with the desirable property of stability to ultra-violet radiation is poly(vinyl fluoride): this material is being suggested for outdoor applications, for example, protective veneers and greenhouse glazing.

Before leaving the field of rigid plastics, current trends in fabrication should be mentioned. Over the past ten years these seem to be the increasing use of thermoplastic materials compared with thermosetting and the increased size of the units fabricated. Injection moulding machines with a shot capacity of approximately 20 lb (based on polystyrene) are becoming available, and a machine of 50 lb shot capacity has been produced. There seems to be no reason why these sizes are at all limiting, and, clearly, this leads to the production by injection moulding of very large units, so that the era of plastics as structural materials replacing metal and wood (for example, in furniture) seems to be imminent. Other fabrication techniques have also advanced rapidly, and new methods, such as vacuum forming of sheets and foils, have become firmly established.

The changes which have come about in the rubber industry, and more particularly in foams, will now be considered briefly. Up to 1939 almost all the rubber used in the world was derived from the rubber tree, but, for strategic reasons, the 1939-45 war saw the rapid development of general purpose synthetic rubber (GR-S, now known as SBR) to a level exceeding half a million tons a year. Whilst there was some retrenchment of natural rubber after the war, the world production of SBR is now running at a level exceeding the peak output of the war years. Oil resistant butadiene-acrylonitrile copolymer rubbers, firmly established before the 1939-45 war, particularly in Germany, are being used increasingly, and polychloroprene has progress similarly. The theme of this paper is, however, new materials, and some of the new developments in the rubber field are extremely interesting. The last 3-4 years have seen considerable activity in the development of synthetic natural rubber, cis 1,4-polyisoprene and the butadiene analogue, cis 1,4-polybutadiene. The former is likely to be a direct substitute for natural rubber, but the latter presents some properties of particular interest to the tyre manufacturer, namely, good tread wear and low heat build-up (high resilience). These characteristics are important in truck and heavy duty tyres. Still in the development stage are the ethylene-propylene copolymer rubbers. These have interesting properties potentially, but uncertainty in their processing behaviour might retard their universal acceptance.

A considerable number of special rubbers have been prepared and marketed, particularly for use at high temperatures, for example, in the aircraft and missile fields. Silicones are perhaps the best known polymers in this class, but newer materials, praticularly fluorine derivatives, have exceptional high temperature behaviour in the presence of oils, fuels and hydraulic fluids. Examples are hexafluoropropene-vinylidene fluoride copolymer, poly(dihydroperfluoro butyl acrylate), and, of lesser resistance, polytrifluorochloroethylene.

The decade 1950-1960 has seen an enormous increase in the use of expanded or foamed products. Rigid thermoplastics such as polystyrene and polythene are being used in the expanded form. Examples are thermal insulation for the former, and electrical insulation for the latter, but the phenomenal advance has been in flexible foams, particularly in polyurethanes. An extremely easy fabrication process and the durability of the products have led to their widespread use.

Finally, a word about fibres. Nylon and " Terylene " have found wide acceptance both in apparel and industrial applications. More recently, fibres based on acrylonitrile have been produced roughly covering the same field. It seems likely that the next development will be the widespread acceptance of the polyolefines in the fibre field. Polythene already finds some use, and

polypropylene is likely to find large outlets in all branches of the industry, from apparel on the one hand to ropes and cordages on the other. In the latter applications, it will be in direct competition with sisal and hemp: this replacement can only be envisaged because of the technical advantages of the synthetic product in its low density, great strength, non-absorption of water, and general chemical inertness.

Notes and News

Professor A. M. Tyndall

It is with very great regret that we learned, as we went to press, of the death of Professor A. M. Tyndall (*Honorary Fellow*), at the age of 80 years. Professor Tyndall died in his sleep on October 29.

An account of Professor Tyndall's outstanding work for The Institute of Physics will be published in the December *Bulletin*.

Annual Exhibition

The annual exhibition of scientific instruments and apparatus will be held in the Royal Horticultural Society's Halls in London on January 15-19 next. Full particulars and members' tickets are included with this issue of the *Bulletin*. Non-members may obtain tickets from the Secretary.

The British Nuclear Energy Society

On January 1 next the British Nuclear Energy Society will be established as a successor to the British Nuclear Energy Conference which was founded in 1955 by the major engineering institutions and The Institute of Physics. Later it was joined by other bodies. Members of The Institute of Physics and The Physical Society of all grades are eligible to join the new Society. The annual subscription, which includes the journal is £2 10s. p.a. Those interested are invited to apply immediately for membership, on the form enclosed with this issue, so that they may participate in the activities of the new body from its foundation.

The new Society intends to provide a central forum for the discussion of nuclear energy and related scientific and technical matters, where the interchange of ideas and information may take place between those trained in different disciplines; for example subjects such as health physics, computer techniques, and measurement and control will be discussed. The Institution of Civil Engineers have made their premises in Great George Street, Westminster, available as a meeting place, and a regular program of papers, lectures, symposia and informal discussions is being planned.

The Society will (like its predecessor) publish a quarterly journal which in addition to reprinting a wide range of important papers will also contain orginal papers and discussion on them, information and authoritative scientific and technological comment on developments in nuclear energy throughout the world, and reports on the proceedings of meetings of the Society. The first issue of this journal is planned for January, 1962.

Membership of the Society will be open on application to members of all classes of the constituent societies of its predecessor and to all who satisfy the Board that they are " actively engaged in the professional, scientific, or technical aspects of the application of nuclear energy and ancillary subjects ".

To ensure continuity for the first year the affairs of the Society will be managed by the present Board of the British Nuclear Energy Conference. The Chairman is Sir Leonard Owen and The Institute of Physics and The Physical Society has three seats on the present Board.

The first of the monthly meetings which have been arranged will be held in London on January 31 when papers on " Plutonium fuel for nuclear power " will be read and discussed. The second meeting is on February 28, also in London and the subject is " The disposal of waste fission products ".

Parsons Memorial Lecture

Members of the Institute and Society will be welcome at Professor M. W. Thring's Parsons Memorial Lecture on "Magnetohydrodynamics" to be delivered at 5.30 p.m. (tea at 5 p.m.) on Thursday, 7 December next in the Lecture Theatre of The Institution of Electrical Engineers, Savoy Place, London, W.C.2. No tickets are required.

Jubilee of the Atomic Nucleus

The Science Museum has set up a small group of exhibits to illustrate various theories of atomic structure. The exhibits have been on view from November 3 in the Atomic Physics Section of the Museum on the top floor. They include a group of models of atoms as visualized by J. J. Thomson before Rutherford's theory; a further group illustrating Rutherford-Bohr atoms and several historic photographs relating to Rutherford's great Manchester period of research.

Health Physics

Dr. W. G. Marley and Mr. R. Oliver attended, on behalf of the Institute and Society, a meeting on October 3, 1961, organized by the Health Physics Sub-Committee of the Hospital Physicists' Association to discuss the scientific needs of health physicists and the possible action to be taken to fulfil those needs. The meeting was attended by representatives of The British Occupational Hygiene Society, The Institute of Physics and The Physical Society, The British Institute of Radiology and The Hospital Physicists' Association.

The possible role of these four bodies in catering for the scientific needs of health physicists was discussed and short statements of the policies of these bodies were made by the representatives. The British Occupational Hygiene Society had held scientific meetings in the field of health physics and The Institution of Electrical Engineers (which was not represented) occasionally held symposia on radiation measuring instruments. The British Institute of Radiology has considered the formation of a radiobiology group. There was general concurrence that the radiobiological aspects of the subject were probably already adequately catered for by the existence of the Association for Radiation Research. Great emphasis was laid in the discussion on the diversity in the basic scientific disciplines of persons engaged in work on health physics, which included not only persons basically trained in physics, but also chemists, engineers and a few biologists and medically qualified persons.

It was estimated that about a dozen health physicists in the U.K. were members of the Health Physics Society (based in the U.S.) and there had been continuing negotiations with health physicists in other European countries aimed at the formation of a European Health Physics Society possibly affiliated with the U.S. Society. Despite considerable enthusiasm in several European countries, it had not been found possible so far to form a European Society, although it was understood that about three European countries were forming a national group affiliated with the Society in the U.S.

The meeting reached general agreement that there would be considerable difficulty in catering for the needs of such an inhomogenous group in one society. It was agreed that there might be considerable difficulty in holding together a scientific group under the aegis of any one society. It was proposed therefore that the societies represented should collaborate in the running of one or two symposia in the field of health physics and that any further steps that might be taken should be deferred until the lessons learned from these symposia were known. Particulars of any symposia arranged will be announced in the *Bulletin*.

Symposium on Electromagnetic Theory and Antennas

A Symposium on Electromagnetic Theory and Antennas will be held at the Technical University of Denmark, Copenhagen, from Monday, June 25, to Saturday, June 30, 1962, both days inclusive. The symposium will be open to any interested person from any country.

The symposium is sponsored by The International Scientific Radio Union (U.R.S.I.), The Technical University of Denmark, The Danish Academy of Technical Sciences, and The Danish National Committee of U.R.S.I. Financial aid for arranging the symposium has been given by the International Union and by Danish firms, institutions and foundations. Additional papers may be accepted for presentation. These should be sent not later than December 1 to The Technical Program Committee at The Technical University of Denmark, Øster Voldgade 10 G, Copenhagen K, Denmark (from whom further details may be obtained) and should be in the form of a three-page summary containing not less than 800 and not more than 1,200 words.

Ionizing Radiation Hazards

Six orders were published on September 15, 1961 which had been made by the Minister of Labour under the Ionizing Radiations (Sealed Sources) Regulations, 1961. These Orders, which come into force on February 1, 1962, prescribe the particulars to be kept of maximum permissible radiation doses and of doses received by each worker designated as a "classified worker" under the Regulations, of medical examinations of such workers, and of tests of instruments used to check radiation levels.

The method of testing a sealed source for leakage is stipulated and the level of leakage is laid down at which such a source must be taken out of use until it has been repaired. The form of the record, which an employer must give to a worker leaving his employment is laid down, as are the particulars which are to be included in certificates of results of examination of photographic films worn by workers to measure any exposure to ionizing radiations.

Forms, including explanatory notes, will be available later in the year for recording the particulars kept under the Orders. They will be on sale from H.M. Stationery Office or through any bookseller.

Non-destructive Testing

The Fourth International Conference on Non-destructive Testing is to be held in London from September 9 to 13, 1963. The Council of The Institution of Mechanical Engineers have agreed to arrange the Conference which is sponsored by the British National Committee for Non-destructive Testing. Accordingly the Council have set up an Organizing Committee in collaboration with the British National Committee to plan this Conference. All inquiries should be addressed to The Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London, S.W.1.

OiS Club Scheme

The Optical Society of America has been translating *Optika i Spektroskopiya* and distributing this monthly journal free—thanks to an NSF grant—to all O.S.A. members and subscribers to the *Journal of the Optical Society of America*. This free distribution was an experiment for three years.

The Optical Society has now evolved a scheme (OiS Club) which will permit members of various societies (including the Institute and Society) to obtain *Optics and Spectroscopy* at an annual subscription of $11.00. Orders should be sent direct to the Assistant Secretary, O.S.A., 1155 16th Street, N.W., Washington 6, D.C.

Letter to the Editor

Students' Essays

Many physics masters will have read with interest Professor Lipson's article "Students Essays" (August, 1961, issue). Your readers may be interested in a similar experiment being carried out in this Grammar School at which 60 boys sat for the "A" level examination in physics this year.

Boys write four or five essays per year for each of the three years in the sixth form on topics rather more factual than those to which Professor Lipson refers. Such topics as "The Conservation of Energy", "Friction", "History of Illumination" and "Historical Biographies" are chosen. In the third year the topics are more difficult; "Interference", "Colour in Nature", and "Measurement of Distances less than one cm" are examples.

Masters give some guidance to boys before they begin their work; to the extent of suggesting reference books and a framework for the essay. Not all boys write on the same subject at the same time, and indeed a boy is allowed to make his own choice if he has special interests.

We have found these essays to be interesting and readable. We do in fact sometimes ask that an essay should be read aloud in a class. We find grammatical and spelling mistakes agreeing very largely with those often found in G.C.E. examiners' reports, but there are few factual errors.

Marking is not burdensome, though it takes time. An assessment is given based on the criteria of interest, coverage and general presentation, for we find that even senior boys welcome grading.

From essay writing of this sort boys learn how to use a library and how to précis from books: skills which should be useful at the university later.

We cannot claim, nor is it our intention, that this work will improve G.C.E. results, but it does enable students to digest a topic and see it in the wider context of physics. Learning of this sort is a useful antidote to the pre-digested feeding which examination preparation often involves; indeed the student sees aspects of his subject in much the same way as a teacher must when he prepares a lesson and anticipates awkward questions.

There is already local encouragement to essay writing of this sort. The Bradford Civic Society, in connection with its Christmas lectures, invites such essays. Boys appreciate opportunities for competitive essay writing and it would be a valuable thing if this kind of incentive could be extended, perhaps by building a bridge between this local competitive essay writing and the kind of competition which the discovery essay promotes: which is at a standard much higher than that which many boys can achieve.

COLIN A. CROFTS (*A.Inst.P.*).
Huddersfield New College.

The Institute and Society
is arranging a Conference on

Diffusion and mass transport in solids

at

THE UNIVERSITY OF READING

on

APRIL 10-11, 1962

Correspondence regarding the program should be addressed to Dr. B. L. Evans, J. J. Thomson Physical Laboratory, Whiteknights Park, Reading, Berks.

The Conference will be residential. Further particulars and application forms will be available in January, 1962, from the Administration Assistant of the Institute and Society.

The Institute and Society,
on behalf of
The International Union of Pure and
Applied Physics and the
British National Committee for Physics
is arranging a

Conference on the

Physics of Semiconductors

at the

UNIVERSITY OF EXETER

on

JULY, 16-20, 1962

It is expected that applications to attend will exceed the accommodation available and early application is therefore recommended. Details may be obtained from the Administration Assistant of the Institute and Society.

National Certificates in Applied Physics: 1961 Examinations

The rate of growth of the number of candidates for National Certificates in Applied Physics continues to be very satisfactory, as the following figures show.

	1954	*1955*	*1956*	*1957*	*1958*	*1959*	*1960*	*1961*
Candidates for Higher Certificate	75	82	146	182	246	296	355	455
Candidates for Ordinary Certificate	206	309	424	456	637	820	914	987

Details of the 1961 results are given below. The certificates are awarded jointly by the Institute and Society and the Ministry of Education, the Scottish Education Department or the Northern Ireland Ministry of Education. The Institute and Society is responsible, through its assessors, for the maintenance of the standard of the final examination.

This year the assessors were:—

England, Wales and Northern Ireland

Physics - - - Professor J. D. Craggs
Applied Physics - Dr. J. M. Valentine
Mathematics - - Dr. J. Crank

Scotland

All three subjects - Dr. J. M. Valentine

Candidates who reach a sufficiently high standard in the examinations for the Higher National Certificate are given exemption from Part I of the Graduateship Examination; the number of candidates securing such exemption is shown for each college.

In the following list, " Failures " includes a few candidates who were absent from the examinations.

Full details of courses for these certificates may be obtained from the Deputy Secretary.

	Ordinary National Certificate			**Higher National Certificate**						
							Distinctions			*Exempt*
College	*Candidates*	*Passes*	*Failures*	*Candidates*	*Passes*	*Failures*	*Physics*	*Applied Physics*	*Mathematics*	*from Part I*
(*a*) ENGLAND AND WALES										
Acton: Brunel College of Technology	—	—	—	16	13	3	—	—	2	5
Bedford: The Mander College	11	10	1	—	—	—	—	—	—	—
Birmingham: College of Advanced Technology	—	—	—	15	6	9	—	—	1	3
Birmingham: Matthew Boulton Technical College	30	18	12	—	—	—	—	—	—	—
Bournemouth: Municipal College of Technology and Commerce	35	24	11	14	10	4	—	1	—	3
Brighton: College of Technology	7	5	2	9	5	4	—	—	—	3
Bristol: College of Science and Technology ...	—	—	—	6	3	3	—	—	1	1
Bristol Technical College	17	13	4	—	—	—	—	—	—	—
Cambridge: Cambridgeshire College of Arts and Technology	8	7	1	5**	3	1	—	—	2	3
Cardiff: Llandaff Technical College	5	4	1	—	—	—	—	—	—	—
Cardigan: The County Secondary School ...	9	4	5	—	—	—	—	—	—	—
Chelmsford: Mid-Essex Technical College ...	7	5	2	4	3	1	1	—	2	2
Cheltenham: North Gloucestershire Technical College	2	1	1	—	—	—	—	—	—	—
Connah's Quay: Flintshire Technical College	6	4	2	—	—	—	—	—	—	—
Coventry: Lanchester College of Technology ...	9	8	1	—	—	—	—	—	—	—
Crosskeys: The Technical College of Monmouthshire	12	11	1	—	—	—	—	—	—	—
Croydon: Technical College	26	24	2	19	7	12	2	1	1	4
Dagenham: South East Essex Technical College	8	6	2	—	—	—	—	—	—	—
Derby: College of Technology	9	7	2	7	6	1	1	1	4	4
Ewell: County Technical College	10	8	2	—	—	—	—	—	—	—
Farnborough: Technical College	71	57	14	22	21	1	5	—	4	14
Gloucester: Technical College	6	5	1	—	—	—	—	—	—	—
Guildford: County Technical College	13	12	1	22	16	6	2	2	2	11
Harlow: College of Further Education ...	9	7	2	—	—	—	—	—	—	—
Harrow: Technical College and School of Art	21	18	3	—	—	—	—	—	—	—

College	Candidates	Passes	Failures	Candidates	Passes	Failures	Distinctions: Physics	Applied Physics	Mathematics	Exempt from Part I
Kettering: Technical College	8	5	3	—	—	—	—	—	—	—
Kingston-upon-Thames: Technical College ...	48	38	10	15	13	2	—	1	1	4
Leeds: College of Technology	6	4	2	9	7	2	—	—	4	4
Leicester: College of Technology and Commerce	8	7	1	10	9	1	1	—	3	6
Letchworth: College of Technology	30	26	4	20	12	8	—	—	5	—
Liverpool : College of Technology	47	31	16	19	12	7	2	1	2	5
London:										
Northampton College of Advanced Technology	—	—	—	20	16	4	—	—	3	7
Northern Polytechnic	37	22	15	7	6	1	—	1	—	3
South-East London Technical College ...	72	39	33	30	26	4	2	3	2	10
Newbury: South Berkshire College of Further Education	64	41	23	—	—	—	—	—	—	—
Newport: Newport and Monmouthshire College of Technology	—	—	—	7	4	3	—	—	1	3
Oxford: College of Technology...	49	35	14	25	17	8	—	—	2	3
Preston: Harris College of Further Education	14	8	6	8	7	1	1	1	1	6
Reading: Technical College	26	12	14	36	29	7	1	—	4	8
Rotherham: College of Technology	21	19	2	8	6	2	—	2	2	2
Rugby:										
College of Engineering Technology	—	—	—	15	12	3	1	—	—	3
College of Further Education	8	5	3	—	—	—	—	—	—	—
Salford: Technical College (Peel Park) ...	30*	20	9	—	—	—	—	—	—	—
Salford: College of Advanced Technology ...	—	—	—	16	7	9	—	—	—	1
Salisbury and South Wiltshire: College of Further Education	9	5	4	—	—	—	—	—	—	—
Slough: College of Further Education ...	9	4	5	—	—	—	—	—	—	—
Southend-on-Sea: Municipal College ...	18	12	6	16	13	3	—	—	1	3
Stockport: College of Further Education ...	7	4	3	—	—	—	—	—	—	—
Stoke-on-Trent: North Staffordshire College of Technology	12	7	5	5	3	2	—	—	2	2
Sunderland: Technical College...	34	19	15	11	10	1	2	1	2	9
Swansea: College of Technology	7	6	1	7	4	3	—	—	—	2
Watford: Technical College	13	11	2	—	—	—	—	—	—	—
Whitehaven: College of Further Education ...	13	10	3	4	4	—	—	—	1	2
Worcester: College of Further Education ...	14*	8	5	6	4	2	—	—	—	1
TOTAL	935	656	277	433	314	118	21	15	55	137
	[47 Colleges]					[32 Colleges]				
(*b*) NORTHERN IRELAND										
Belfast: College of Technology	4	4	—	—	—	—	—	—		—
	[one College]									
(*c*) SCOTLAND										
Aberdeen:										
Robert Gordon's Technical College	2	2	—	6	5	1	—	—	—	2
Thurso Technical College	6	6§§	—	—	—	—	—	—	—	—
Coatbridge: Technical College	5	4***‡	1	—	—	—	—	—	—	—
Dundee: Technical College	7	4	3††	3	2	1	—	—	—	—
Edinburgh: Heriot-Watt College	5	3§§	2	—	—	—	—	—	—	—
Paisley: Technical College	23	12§***	11†††	13	12‡	1†	1	—	—	5
TOTAL	48	31	17	22	19	3	1	—	—	7
	[6 Colleges]					[3 Colleges]				
GRAND TOTAL ...	987	691	294	455	333	121	22	15	55	144
	[54 Colleges]					[35 Colleges]				

* includes one result pending
** includes one special decision equivalent to reference in one subject.
*** includes one candidate who has gained special mention in Applied Physics.
† includes one candidate referred in one subject.
‡ includes one candidate who has gained distinction in the whole examination.
§ includes one candidate who has gained special mention in Mathematics.

NOTE: "Special Mention" in Scotland is equivalent to "Distinction" in England and Wales; in Scotland, "Distinction" is awarded for outstanding performance in the whole examination.

Reviews of Books

DIFFERENTIAL EQUATIONS FOR ENGINEERS AND SCIENTISTS

By C. G. Lambe and C. J. Tranter

London: The English Universities Press Ltd. Pp. xi + 372. Price 30s.

Some differential equations are amenable to solution by the older classical methods, for others, integral transforms are more suitable, but often solutions can only be obtained by graphical or numerical methods. What the authors of this book have done is to bring a selection of techniques together in one volume for solving both ordinary and partial differential equations. Great emphasis is placed on applications to practical problems.

The book is intended primarily for students reading for a first degree or its equivalent in science or engineering and in the reviewer's opinion it is admirably suitable for this purpose. The early chapters deal mainly with traditional methods of solving first order differential equations, linear equations with constant coefficients and simultaneous equations. These are followed by accounts of series solutions and the more important functions of mathematical physics including Legendre and Bessel functions, Chebyshev, Laguerre and Hermite polynomials. The hypergeometric equation receives considerable attention.

The solution of partial differential equations is discussed first by the method of separation of variables and then by integral transforms. The chapter on transforms is quite extensive and includes those of Laplace, Fourier and Hankel and also finite transforms. Chapter 9 opens with accounts of the method of isoclinals and of phase-plane diagrams. There follow introductions to the solution of ordinary differential equations by Taylor's series, Picard's, Euler's, Runge-Kutta, Adams-Bashforth and Milne's methods. High-speed computers are mentioned very briefly. A whole chapter is devoted to relaxation techniques for two-point boundary problems and for partial differential equations. The final chapter is an introduction to non-linear differential equations.

Features which add considerably to the value of the book are the straightforward, well-pruned presentation and the inclusion of nearly 900 worked examples and exercises with answers. The fact that the majority of these require the student to express a physical problem in the form of a differential equation before proceeding to solve it is much to be recommended. So also is the general emphasis on solutions which satisfy boundary conditions as of course they always must in physics and engineering. With one notable exception, the reviewer is largely in agreement with the authors' selection of material for students at this level. Could not students' valuable time be saved, however, by omitting the outmoded method of finding a particular integral by the use of the operator D ? This is textbook stuff which should no longer be included among practical methods. The space devoted to it would be better taken up by just a hint of the use of integration formulae based on central differences. The authors and publishers deserve to be commended on this comprehensive and attractively produced account of a branch of mathematics which has such widespread practical application.

J. Crank.

ELECTRONIC, RADIO, AND MICROWAVE PHYSICS

By D. E. Clark and H. J. Mead

London: Heywood and Co. Ltd. Pp. viii + 521. Price 130s.

On first approaching this book one is at a loss to know what it is about and for whom it is written. The title does not convey any very precise information. Indeed the title on the dust cover differs in punctuation from that on the title page and one is left wondering whether the book deals with one subject or three. The preface states " In preparing this book the authors have borne in mind the requirements of physics and technological students at colleges and polytechnics. With suitable choice of sections, material may be found of interest to students preparing for examinations such as the B.Sc. final year Physics, Diploma and advanced Diploma in Technology, B.Sc. final year Engineering, M.Sc., etc. Greater stress has been placed on the importance of fundamental principles rather than on special applications, and in this way the authors feel that the book will more satisfactorily fill the role of a reference work for those engaged in the fields of electronics or microwave physics ". This now gives the reader the impression that the authors themselves are not certain of their purpose. Further examination confirms this impression. Apart from two chapters on Spectroscopy at Radio and Microwave Frequencies and Properties of Dielectrics and Ferrites, the list of contents suggests a general textbook on radio and electronics, including microwaves. The first half deals with electromagnetic theory, transmission lines, waveguides, propagation, networks and filters. The two chapters on spectroscopy and dielectrics and ferrites are sandwiched between waveguides and propagation. The remainder of the book is on valves, amplifiers, oscillators, microwave valves and noise. The choice of material seems to be rather arbitrary. More than half of two chapters on conventional valve amplifiers deals with various aspects of frequency response. There are many pages of unrelieved analysis on shunt compensation, series compensation, filter coupling and distributed amplifiers. Yet there appears to be no mention of d.c. amplification or balanced amplifiers; the cathode follower is dismissed in one page and most of that is taken up with algebra. More surprisingly in a book of 521 pages published in 1961 and claiming to deal with the physics of electronics and radio, there is not one word on semiconductors or transistors, nor are gas discharge tubes mentioned. Some of the sections included might have been appropriate to an engineering handbook but there is very little to appeal to physicists. Some of the illustrations (e.g. figures 9.19, 9.28 and 9.34) are very poor. The price is exorbitant.

M. R. Gavin.

TIME-HARMONIC ELECTROMAGNETIC FIELDS

By Roger F. Harrington

New York and London: McGraw-Hill Publishing Co. Ltd. Pp. xi + 480. Price 104s. 6d.

As the title shows, only sinusoidally time-varying fields are considered (" a.c. theory ") in this work which is of graduate standard according to the introduction, although some of it would come within the compass of final year university electrical engineering or physics courses. The treatment is of course mathematical and virtually no reference is made to detailed practical cases.

The first two chapters deal with basic theory from a fairly elementary to an advanced level. The third chapter, which is on some theorems and concepts, is on similar lines and leads to chapter 4 on plane wave functions in which wave guides are treated well. Chapters 5 and 6 are complementary to the latter; the former is on cylindrical wave functions (space as a wave guide, etc.). The final two chapters are on perturbational and variation techniques and on microwave networks. There are several mathematical appendices and notable selections of problems at the end of each chapter.

J. D. Craggs.

AN INTRODUCTION TO THE THEORY AND PRACTICE OF TRANSISTORS

By J. R. Tillman and F. F. Roberts

London: Sir Isaac Pitman & Sons, Ltd. Pp. xxii + 340. Price 57s. 6d.

The last few years have seen a vast increase in the production of semiconductor devices of various kinds, and these devices are constantly finding new applications in all branches of physics. A physicist nowadays frequently finds that he must have at least an elementary knowledge of both the basic physical theory and the circuit technology of semiconductor devices. There are a number of good textbooks which deal with the transistor as a circuit element having specified properties; and there are also excellent books on the electrical properties of semiconductors. The present book is an attempt, and in my opinion a successful one, to unite in a single volume of just over 300 pages a satisfactory account of both these aspects of the subject.

The first 70 pages present the basic theory of the electrical properties of semiconductors. This section can be commended to any physicist who desires a succint introduction to the subject. The authors do not make light of the difficulties of the physical theories: the text is not easy, but should be understood by any competent physicist. The authors occasionally make use of electrical network theory to describe the mathematics of a quantum-mechanical problem. This may be a hindrance rather than a help to the average physicist, but is justified since the book is addressed also to electrical engineers. A chapter on the $p - n$ junction is followed by a discussion of the junction transistor. A 3-dimensional model of a transistor is discussed, and its electrical properties are deduced. Zener and avalanche effects are also discussed.

The second half of the book, dealing with the technology of transistors, begins with 40 pages describing the construction of transistors from the zone refining of the original material. This is followed by a critical discussion of the various equivalent circuits proposed for transistors, and a description of methods of measuring their properties. The book concludes with a chapter of 90 pages describing the applications of diodes and transistors as amplifiers, oscillators, switches, logical elements, and waveform generators. The circuits described form a good cross-section of the field of application of transistors, and the descriptions given are sufficiently detailed to enable the reader to make a preliminary design for a proposed piece of equipment.

The book represents a successful union of basic physical theory and electronics technology, and can be recommended to all physicists and electrical engineers interested in this subject.

T. B. Rymer.

NUCLEAR REACTOR PHYSICS

By S. E. Liverhant

London and New York: John Wiley & Sons, Ltd. Pp. xiv + 447. Price 78s.

This book is an introduction to the subject of reactor physics and aims to acquaint the reader with the necessary fundamental ideas and basic concepts. It assumes little knowledge of nuclear physics or mathematics and may be suitable for engineering students who require a physical background to a nuclear engineering course.

The first third of the book is devoted to a quite excellent discussion of important aspects of nuclear physics—nuclear forces, reactions and the fission process. In fact the book is rather out of balance in this respect for the sections actually concerned with reactor physics are by comparison far less thorough.

The slowing down and thermalization of neutrons, criticality and reactor kinetics are all considered at a fairly elementary level. The movement of neutrons is taken to obey a Diffusion type law and the Transport equation is not discussed. The treatment is satisfactory, although the effective resonance integral introduced is not that normally considered and it is rather surprising to learn of a 700 MW reactor at the Oak Ridge National Laboratory. The book concludes with sections on nuclear radiation and discusses its detection and effects.

The overall presentation of the material is good. The text is well illustrated with many diagrams, figures and worked examples. A list of problems and an adequate bibliography appear at the end of each of the fourteen chapters.

J. G. Tyror.

ANALYSING QUALITATIVE DATA

By A. E. Maxwell

London: Methuen & Co. Ltd. Pp. 163. Price 16s.

The author of this book is senior lecturer in statistics at the Institute of Psychiatry of the University of London. To complement an earlier volume on *Experimental Design in Psychology and the Medical Sciences*, he has written this account of the application of the chi-square test to various statistical investigations in psychology, psychiatry and

social medicine. To one not expert in these fields it is of great interest to find how widely these fundamental statistical techniques are being applied. There are several chapters dealing with contingency tables of different types, followed by others on tests of goodness of fit, rank correlation techniques and miscellaneous tests of significance.

It is well-written and lucid and should be of great help to research workers. It is a valuable addition to the Methuen *Monographs on Applied Probability and Statistics*.

J. Topping.

AN INTRODUCTION TO CELESTIAL MECHANICS

By Theodore E. Sterne

New York and London: Interscience Publishers, Inc. Pp. xi + 206. Price (Paper Edition) 19s. (Cloth Edition) 34s.

Recognizing that to-day there are few specialists in Celestial Mechanics, while at the same time many physicists and engineers will meet its problems in connection with missiles, satellites and space vehicles, the author has here collected, in accessible form, the main results of two and a half centuries of work since Newton on planetary orbits. Obviously 200 pages will allow only the essential steps of the more important methods and a mere outline of others. Even so, the equations rapidly become clumsy once the simple elliptic orbit is passed, and the book is essentially for those directly concerned with this type of calculation. For such it will be invaluable as a first reference book.

Starting with elliptic motion it goes on to consider the attraction of irregular bodies. Here it is interesting to note that the effect of the non-spherical form of the earth on the motion of a close satellite is more important than the attractions of either the sun or the moon. A chapter on coordinate systems in space is followed by one which develops the dynamics of Lagrange's and Hamilton's equations and contact transformations in order to apply them in the discussion of general perturbations.

The author spends a couple of pages discussing the significance of the " secular terms " in the series expansions of the solution for the perturbed motion, in relation to the long term stability of the orbital motion, arguing that the secular terms arise merely from the method of expansion, and their occurrence has no significance in relation to long-term behaviour of the system. The present writer would have thought that this question had been settled in the manner suggested by the author, when Lindstedt, adapting the methods to the equations of non-linear oscillations, showed how to develop series without introducing secular terms.

The fifth chapter deals with the motion of artificial earth satellites and a final chapter considers the numerical integration of ordinary differential equations. Although rather apart from the rest of the book this last chapter is interesting for its treatment of the errors arising in step-by-step numerical solutions. In considering the integration of the equations of motion of a close earth-satellite it is estimated that to retain an accuracy of six decimal digits after 600 days of satellite motion, 15 decimal digits would have to be retained throughout the work, and it would take about 11 days to complete the calculation on a high speed machine such as the IBM 704, if the machine were operated for 40 hours a week. That such calculations can even be contemplated is a vivid indication of the change of outlook which the availability of such machines is producing.

A. W. Gillies.

ESSENTIALS OF HEAT

By O. M. White

London: Cleaver-Hume Press Ltd. Pp. vii + 208. Price 15s.

ESSENTIALS OF LIGHT

By F. J. H. Dibdin

London: Cleaver-Hume Press Ltd. Pp. viii + 240. Price 15s.

Essentials of Heat is the first volume of a planned five-volume course in physics to G.C.E., "A" level standard. The claim for the complete course is that it " has been patterned to the latest demands of examiners after a very careful study of the papers of all the chief Examining Boards ". The reviewer has many doubts of this being the best approach. However, the book accomplishes what it claims, namely, to cover the basic content of the syllabus. There is no doubt that it is up-to-date in many respects and that the subject matter is well presented, but one is startled to see Hope's apparatus, the weight thermometer, the dilatometer and Matthiessen's sinker all illustrated on adjacent pages.

The diagrams, however, are not so good. In many cases the proportions are so bad as to be misleading. To give two examples, Fig. 1.5, in spite of some dimensions being given in the text, quite a false impression of the size of the thermometer bulb and the bore of the connecting tube can be obtained by a student. Further, in Fig. 2.9, the thermometer gives a false impression of the size of the whole apparatus and tube A looks like two narrow tubes.

The tendency to-day in teaching at this level is to pay more regard to significant figures. The answers to the well-selected problems at the end of each chapter are given to four significant figures where, very often, the quantities in the questions are expressed to two significant figures only.

These minor defects can well be eliminated in a new printing, as can a few little blemishes, e.g. no units are given to specific heat, after stating in the text that it is now more commonly defined as an amount of heat: the curves in Fig. 4.4 are inaccurate.

Essentials of Light is the second volume of the series.

The book is well written and the diagrams are exceptionally clear. Similar misuse of significant figures occurs in this volume. Also it is now considered unwise to employ fractions in examples. Several of the diagrams in chapter 9 would certainly " not satisfy the examiners ", for the second images are just inserted without their true positions being located by construction. Again, Fig. 5.15 is a little confusing to a student without some special explanation, for the rays appear to suffer double refraction at the slide. Is it not much better to derive $D = (\mu - 1)\,A$ from first principles than from the formula for minimum deviation? By doing so, the independence of D upon i, provided i is small, is clearly established.

The book forms another, and quite worthy, member of the family of " A " level texts on optics.

W. Ashhurst.

Forthcoming Institute and Society Meetings

November 17 and 18. At London. X-ray Analysis Group.
Autumn Conference on **Imperfections in crystals.** At Institution of Mechanical Engineers.
Registration is necessary.

November 20 at 7.00 p.m. At Manchester. Manchester and District Branch.
Neutron diffraction by Dr. G. E. Bacon, F.Inst.P. (*Atomic Energy Research Establishment, Harwell*). At the College of Science and Technology.

November 24 at 5.15 p.m. At Swansea. South Wales Branch.
Primary cosmic rays by Professor J. G. Wilson, F.Inst.P. (*University of Leeds*). At University College.

November 29 at 6.15 p.m. At Newcastle. North Eastern Branch.
The origin of life in solar systems by Professor J. D. Bernal, F.Inst.P., F.R.S. (*Birkbeck College, London*). At King's College.

November 29 at 5.00 p.m. At Leeds. Yorkshire Branch.
Traffic management in London by Dr. G. Charlesworth, F.Inst.P. (*Ministry of Transport, London*). At The University.

December 5 at 7.15 p.m. At Glasgow. Scottish Branch.
Chairman's Address on **Some observations on reliability** by Dr. G. Morris, F.Inst.P. (*I.C.I. Nobel Division, Ayrshire*). At The University.

December 6 at 5.30 p.m. At London. Education Group.
The Science Masters Association syllabus by Mr. E. W. Tapper, F.Inst.P. (*University of Bristol*). At Headquarters.

December 8 at 2.30 p.m. At London. Applied Spectroscopy Group.
Recent development on X-ray fluorescence spectroscopy by Dr. J. L. de Vries (*Philips Electrical Ltd., Eindhoven*). At the Royal Aeronautical Society.

December 8 at 2.30 p.m. At London. Electron Microscopy Group.
Report on **Electron microscopy in Japan** by Mr. T. Mulvey (*Associated Electrical Industries Research Laboratory, Aldermaston*) and Dr. M. Whelan, A.Inst.P. (*University of Cambridge*). At Headquarters.

December 8 at 6.00 p.m. At Cardiff. South Wales Branch.
Branch Annual General Meeting followed by a lecture on **Structural studies on fibrous proteins** by Dr. R. E. Burge (*University of London*). At University College.

December 8 at 6.00 p.m. At London. Non-Destructive Testing Group.
The correlation of elastic constants in single crystals and polycrystals by Dr. M. F. Markham (*National Physical Laboratory, Teddington*). At Headquarters.

December 8 at 7.00 p.m. At Bristol. South Western Branch.
Physics in archaeology by Dr. G. N. Fowler (*University of Bristol*). At The University.

December 11 at 2.30 p.m. At London. London and Home Counties Branch.
Static electricity by Dr. P. S. H. Henry, F.Inst.P. (*Shirley Institute, Manchester*). At Headquarters.

December 12 at 6.30 p.m. At Birmingham. Midland Branch.
The observation of radio stars by Dr. P. F. Scott (*University of Cambridge*). At the Midland Institute.

December 12 at 2.30 p.m. At London. Stress Analysis Group.
Half-Day Meeting on **Strain gauges.** At Headquarters.
Registration is necessary.

December 12 at 6.00 p.m. At London. Electronics Group.
Integrated electronics by Dr. J. W. Granville (*Royal Radar Establishment, Malvern*). At Headquarters.

December 13 at 7.00 p.m. At Liverpool. Liverpool and North Wales Branch.
Physics and architecture by Professor J. K. Page (*University of Sheffield*). At The University.

December 13 at 11.00 a.m. At London. Low Temperature Group.
Ferromagnetism and antiferromagnetism. At Headquarters.
Speakers will be announced later.

December 14 at 5.30 p.m. At London. Acoustics Group.
The acoustics of the organ. At Imperial College.
Speaker to be announced later.

December 18 at 7.00 p.m. At Manchester. Manchester and District Branch.
A musician looks at physics by Mr. F. R. Cox, O.B.E., Hon.R.A.M. (*Royal College of Music*). At The University.

December 21 at 2.30 p.m. At London. Optical Group.
Details to be announced later.

The Register

ELECTIONS TO MEMBERSHIP

THE FOLLOWING ELECTIONS WERE MADE BY THE COUNCIL ON OCTOBER 3, 1961

FELLOWSHIP of The Institute of Physics (21)

(a) Transferred from Associateship of The Institute of Physics

Aruja, Endel, B.Sc., Ph.D., Senior Scientific Officer, Building Research Station, Garston, Herts.

Bunton, Marian Helen Hewson, M.Sc., Senior Lecturer in Science, Homerton College, Cambridge.

Greene, David, M.Sc., Ph.D., Principal Physicist, Medical Research Council Unit, Christie Hospital and Holt Radium Institute, Manchester.

Grove, Francis John, B.Sc., Research Physicist, Pilkington Brothers Ltd., St. Helens, Lancs.

Hesketh, Ross Vernon, B.Sc., Ph.D., Experimental Physicist, U.K. Atomic Energy Authority, Thurso, Caithness, Scotland.

McCue, Clarence Gordon, M.Sc., Senior Scientific Officer, Weapons Research Establishment, Salisbury, S. Australia.

McDonnell, John Alexander, B.A., M.Sc., Ph.D., Senior Lecturer, University of Melbourne, Australia.

Newcomb, Thomas Peter, M.Sc., Principal Research Officer, Ferodo Ltd., Cheshire.

Pratt, Alan William, M.Sc., Principal Scientific Officer, Building Research Station, Garston, Watford, Herts.

Pringle, Derek Hair, B.Sc., Ph.D., Chief Physicist, Nuclear Enterprises (G.B.) Ltd., Sighthill, Edinburgh.

Stephenson, Sydney Kenneth, B.Sc.Tech., Deputy Chief Clinical Physicist, Christie Hospital and Holt Radium Institute, Manchester.

Stokes, Alexander Rawson, M.A., Ph.D., Lecturer, King's College, University of London.

Teale, Roger, M.A., Head of Physics Department, North Staffs College of Technology, Stoke-on-Trent, Staffs.

Williams, William Frederick, B.Sc., Ph.D., Head of Physics and Mathematics Department, Norwood Technical College, London.

Wilmot, Philip Daryl, M.Sc., Development Chemist, International Nickel Co. (Mond.) Ltd., London.

Wynn, Norman Ratcliffe, M.A., Head of Physics Development Laboratory, Ilford, Ltd., Ilford, Essex.

(b) Transferred from Fellowship of The Physical Society

Flowers, Brian Hilton, M.A., D.Sc., F.R.S., Langworthy Professor of Physics, University of Manchester.

Jenkins, Alexander, B.Sc., Ph.D., Group Leader, Westinghouse Brake and Signal Co. Ltd., Chippenham, Wilts.

(c) Other Elections

Lewis, John Logan, M.A., Senior Science Master, Malvern College, Worcs.

Moodie, Alexander Forbes, B.Sc., Principal Research Officer, C.S.I.R.O., Melbourne, Australia.

Richards, John Charles Shenstone, B.Sc., Ph.D., Senior Lecturer, University of Aberdeen.

ASSOCIATESHIP of The Institute of Physics (36)

(a) Transferred from Graduateship of The Institute of Physics

Brown, Alexander Campbell, B.Sc., Section Leader, Standard Telephones and Cables Ltd., Footscray, Kent.

Brown, Michael, B.Sc., Experimental Officer, U.K. Atomic Energy Authority, Capenhurst, Chester.

Donegan, Daniel Patrick, Health Physicist, Royal Ordnance Factory, Chorley, Lancs.

Hill, John David, B.Sc., Experimental Officer, Atomic Energy Research Establishment, Harwell, Didcot, Berks.

Hughes, John Alan, B.Sc., Electronic Engineer, Associated Electrical Industries (Rugby) Ltd., Rugby, Warks.

Palmer, Ronald William, B.Sc., Ph.D., Development Physicist, English Electric Valve Co. Ltd., Chelmsford, Essex.

Phillipson, John, B.Sc., Research Physicist, English Sewing Cotton Co., Ltd., Manchester.

Rainford, Frank, B.Sc., Head of Physics Department, Berwick Grammar School, Berwick-upon-Tweed, Northumberland.

Swift, David William, B.Sc., Ph.D., Scientific Co-operator, N.V. Philip's Research Laboratories, Eindhoven, Netherlands.

Wolstenhulme, John Milton, M.A., Quality Controller, Wiggins, Teape & Co. Ltd., High Wycombe, Bucks.

(b) Transferred from Fellowship of The Physical Society

Flynn, Patrick Thomas George, B.Sc., Ph.D., Principal Scientific Officer, Atomic Weapons Research Establishment, Aldermaston, Berks.

Wojcikiewicz, Ewaryst Albin, B.Sc., Reactor Physicist, Central Electricity Generating Board, London.

(c) Transferred from Student of the Institute and Society

Carey, Roy, B.Sc., Ph.D., Lecturer, Lanchester College of Technology, Coventry.

(d) Other Elections

Baker, John Russell, B.A., Senior Science Master, West Bromwich Grammar School.

Ballham, Lewis Stanley, B.Sc., Head of Department of Applied Physics, Stanfield Technical High School, Stoke-on-Trent, Staffs.

Brown, Basil, B.Sc., Ph.D., Senior Lecturer, Royal College of Advanced Technology, Salford, Lancs.

Clifton, John Stephen, M.Sc., Senior Assistant Physicist, University College Hospital, London.

Couzens, Raymond, B.Sc., Scientific Officer, Royal Aircraft Establishment, Farnborough, Hants.

Essenhigh, Robert Henry, M.A., Ph.D., Associate Professor of Combustion Engineering, Pennsylvania State University.

Farmer, Crofton Bernard, B.Sc., Head of Physics Group, Electric and Musical Industries (Electronics) Ltd., Feltham, Middx.

Freeman, Frank Edward, B.Sc., Lecturer, Northampton College of Advanced Technology, London.

Goodman, Peter, M.Sc., Research Officer, C.S.I.R.O., Melbourne, Australia.

Hallam, Graham Charles, B.Sc., Ph.D., Assistant Lecturer, University of Leeds.

Heeley, Eric George Rigby, M.A., Head of Physics Section, Dulwich College, London.

Jordan-Czapska, Wanda, M.Sc., Experimental Officer, Ministry of Defence, London.

Kishore, Lalit, M.Sc., Ph.D., Lecturer, University of Patna, India.

Lewis, Gordon, B.Sc., Assistant Health Physicist, Central Electricity Generating Board, Berkeley, Glos.

Marshall, Henry Thomas George, M.Sc., Senior Lecturer, Willesden Technical College, London.

Nawaz, Shaikh Muhammad, B.Sc., Ph.D., Deputy Director, Pakistan Institute of Cotton Research and Technology, Karachi, Pakistan.

Phillips, William Robert, B.Sc., Ph.D., Lecturer, University of Manchester.

Presland, Anthony Edric Brandon, B.A., B.Sc., Crystallography Section Leader, Nuclear Research Establishment, C. A. Parsons & Co. Ltd., Newcastle-upon-Tyne.

Raumann, Gertrud, B.Sc., Research Officer, The Cotton, Silk and Man Made Fibres Research Association, Didsbury, Manchester.

Rutherford, Thomas Neville, B.Sc., Physicist, U.K. Atomic Energy Authority, Windscale Works, Cumberland.

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Westbrook, Michael Hereward, B.Sc., Head of Electronics Research and Development, Associated Engineering Ltd., Rugby, Warks.

GRADUATESHIP of The Institute of Physics (125)

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Bloomfield, Brian, Assistant Lecturer, Southend-on-Sea Municipal College, Essex.

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Fielder, Michael Louis, B.Sc., Valve Development Engineer, Associated Electrical Industries Ltd., Harlow, Essex.

Gleaves, George Henry, B.Sc., Lecturer, Wigan and District Mining and Technical College.

Greene, David Alan, Experimental Officer, U.K. Atomic Energy Authority, Capenhurst, Chester.

Gresley, Joseph Albert Blackwell, Assistant Experimental Officer, U.K. Atomic Energy Authority, Capenhurst, Chester.

Harness, Ian, Development Assistant, The General Electric Co. Ltd., Cheshire.

Harper, Leslie Richard, Assistant Experimental Officer, Atomic Weapons Research Establishment, Aldermaston, Berks.

Hawkins, Stanley James, Experimental Officer, Ministry of Aviation, E.R.D.E., Waltham Abbey, Essex.

Herrington, Brian David, Laboratory Technician, University of Leeds.

Hewitt, Anthony Frederick, Assistant Experimental Officer, Armament Research and Development Establishment, Sevenoaks, Kent.

Hodges, Terence Alfred, B.Sc., Assistant Experimental Officer, Atomic Energy Research Establishment, Harwell, Didcot, Berks.

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Johnson, Colin David, Senior Assistant, Dunlop Rubber Co. Ltd., Birmingham.

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Lowe, Charles Graham, Research Assistant, British Hat and Allied Feltmakers Research Association, Stockport, Cheshire.

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McGuckin, James Patrick, B.Sc., Assistant Physics Master, The Academy, Ballymena, Co. Antrim.

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Maines, Janet Enid, Dip. Tech., Assistant Experimental Officer, Royal Radar Establishment, Gt. Malvern, Worcs.

Montgomery, Anthony John, B.Sc., A.R.C.S., Research Student, Imperial College, London.

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Neilson, Thomas Christopher, B.Sc., Scientific Officer, U.K. Atomic Energy Authority, Windscale Works, Seascale, Cumb.

Owen, Michael Robert, B.Sc., Assistant Physics Master, Fairham Comprehensive School, Nottingham.

Pearce, Charles George, B.Sc., Senior Research Physicist, B.S.A. Group Research Centre, Kitts Green, Birmingham.

Perkins, James William, B.Sc., Postgraduate Student, University of Bristol.

Plumtree, William Ernest George, B.Sc., Experimental Officer, Imperial College, London.

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Quayle, Donald Victor, B.Sc., Physicist, B.T.R. Industries Ltd., Staffs.

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Roberts, Gareth Gwynn, B.Sc., Research Student, University College of North Wales, Bangor.

Sellers, William Ronald, B.Sc.Tech., Teacher, The Derby School, Bury, Lancs.

Shiner, Patrick George, B.Sc., Team Leader, Richard Thomas & Baldwins Ltd., Worcester.

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Sprung, Donald Whitfield Loyal, B.A., Ph.D., Research Associate, Cornel University, New York, U.S.A.

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Tolfree, David William Leonard, Assistant Experimental Officer, Atomic Weapons Research Establishment, Aldermaston, Berks.

Toy, Mark, B.Sc.Tech., Senior Investigator, British Steel Castings Research Association, Sheffield, Yorks.

Trickett, Brian Arthur, Assistant Experimental Officer, National Institute for Research in Nuclear Science, Harwell, Didcot, Berks.

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Turner, Maurice, B.Sc., Technical Officer, Imperial Chemical Industries Ltd., (Metals Division), Witton, Birmingham.

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Utton, Donald Brian, B.Sc., Research Assistant, University of Southampton.

Warr, Albert John, B.A., Postgraduate Student, University of London.

White, Brian Malcolm, Assistant Experimental Officer, Atomic Energy Research Establishment, Harwell, Didcot, Berks.

Wright, Geoffrey, B.Sc., Assistant Lecturer, South East London Technical College, London.

Wright, John Peter, B.A., Assistant Lecturer, North Staffs. College of Technology, Stoke-on-Trent, Staffs.

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Youngman, Richard Anthony John, B.A., Trainee, Wiggins, Teape Ltd., High Wycombe, Bucks.

(*c*) *Other Elections*

Askill, John, B.Sc., Research Student, University of Reading.

Barker, Michael Charles John, B.Sc., Research Student, University of Nottingham.

Barrass, Thomas Richard, B.Sc., A.R.C.S., Physics Master, Bromsgrove County High School, Worcester.

Barratt, Keith Laybourne, B.Sc., Research Physicist, Pilkington Bros. Ltd., St. Helens, Lancs.

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Brow, Norman James, B.Sc., Physicist, U.K. Atomic Energy Authority, Dumfriesshire.

Burley, Barrington William, B.Sc., Physicist, Land Pyrometers Ltd., Sheffield.

Clayworth, Geoffrey Thomas, B.Sc., Graduate Apprentice, English Electric Valve Co. Ltd., Chelmsford Essex.

Corbett, Sheila Elizabeth, Experimental Officer, Armament Research and Development Establishment, Sevenoaks, Kent.

Cox, Anthony Frederick, B.Sc., Scientific Technical Officer, National Coal Board, Mining Research Establishment, Isleworth, Middx.

Daly, John Taylor, B.Sc., Physicist, Mullard Radio Valve Co. Ltd., Southampton.

Dennis, Brian Roy, B.Sc., Research Student, University of Leeds.

Farr, Christopher Thomas, Assistant Experimental Officer, Royal Aircraft Establishment, Farnborough, Hants.

Griffiths, Angela Margaret, Engineer, Associated Electrical Industries (Manchester) Ltd., Trafford Park, Manchester.

Gumley, Phillip, B.Sc., Assistant Experimental Officer, U.K. Atomic Energy Authority, Capenhurst, Chester

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Haque, Abdul Kader Md. Muzharul,M.Sc., Research Assistant, The Borough Polytechnic, London.

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Hine, Robert James, Scientist, Plessey Co. Ltd., Romsey, Hants.

Horbury, Paul Bertrand Holmes, B.Sc., Assistant Lecturer, North Lindsey Technical College, Scunthorpe, Lincs.

Hudson, Francis Raymond, B.Sc., Scientific Officer, U.K. Atomic Energy Authority, Windscale Works, Seascale, Cumb.

Huggins, Brian George, B.Sc., Lecturer, Walsall and Staffordshire Technical College.

Kershaw, Malcolm Stuart, B.Sc., Computor Development Engineer, Ferranti Ltd., Manchester.

Lewis, Thomas Kenneth, B.Sc., Student, Education Department, University College of North Wales, Bangor.

Maddocks, Colin Dean, B.Sc., Experimental Officer, Imperial Chemical Industries (Hyde) Ltd., Hyde, Cheshire.

Meadows, Richard Guy, M.Sc., Lecturer, The Polytechnic, Regent Street, London.

Mills, Derek Arthur, B.Sc., Physicist, Imperial Chemical Industries (Manchester) Ltd., Dyestuffs Division, Trafford Park, Manchester.

Neale, Ronald George, Assistant Physicist, Mullard Radio Valve Co. Ltd., Mitcham, Surrey.

Nicholson, Brian Frederick, Microwave Physicist, G. & E. Bradley Ltd., Middlesex.

Owen, Geoffrey Peter, B.Sc., Research Student, University of Hull.

Paine, Edwin Walter, B.Sc., Scientist, British Oxygen Company, London.

Panton, Leslie George Terrence, B.Sc., Assistant Experimental Officer, U.K. Atomic Energy Authority, Capenhurst, Chester.

Parker, Antony John, B.A., Research Student, University College of North Staffs, Keele, Staffs.

Purslow, David, Assistant Experimental Officer, Royal Aircraft Establishment, Farnborough, Hants.

Richardson, Frank Ernest, B.Sc., Research Physicist, United Glass Ltd., London.

Roessler, David Martyn, B.Sc., Student, King's College, London.

Rolls, Brian John, Assistant Experimental Officer, Armament Research and Development Establishment, Sevenoaks, Kent.

Samuel, Margaret Josephine, B.Sc., Research Assistant, University College, London.

Smith, George Edwin Ian, B.Sc., Assistant Experimental Officer, U.K. Atomic Energy Authority, Capenhurst, Chester.

Smith, Peter William, B.Sc., Assistant Master, Fairfield Grammar School, Montpelier, Bristol.

Solman, Leslie Roger, B.Sc., Scientific Staff, Research Laboratory, Kodak Ltd., Harrow, Middlesex.

Spackman, Ramon, Assistant Experimental Officer, Atomic Energy Research Establishment, Harwell, Didcot, Berks.

Speer, Robert John, B.Sc., Research Student, University College, London.

Stevens, Derek Clifford, B.Sc., Experimental Officer, Atomic Energy Research Establishment, Harwell, Didcot, Berks.

Styler, John Alfred, B.Sc., Physicist, English Electric Co. Ltd., Whetstone, Leicester.

Taylor, Eric Royston George, Assistant Experimental Officer, Royal Aircraft Establishment, Farnborough, Hants.

Verrall, Alan Frederick Douglas, Technologist, British Scientific Instrument Research Association, Chislehurst, Kent.

Viney, Ian Valentine Francis, B.Sc., Research Student, University of Nottingham.

Walford, Francis John, Experimental Officer, Atomic Weapons Research Establishment, Foulness Island, Essex.

Walkden, Michael William, Assistant Experimental Officer, Royal Aircraft Establishment, Farnborough, Hants.

Watt, Nicol Lumsden, B.Sc., Junior Engineer, Associated Electrical Industries (Manchester) Ltd., Trafford Park, Manchester.

Weinreich, Peter, B.Sc., Research Student, University of Manchester.

Wheeler, Colin, Assistant Experimental Officer, Royal Aircraft Establishment, Farnborough, Hants.

Wheeler, John, B.Sc., Research Assistant, University of Oxford.

Williams, Colin George Bruce, B.Sc., Research Student, University of Birmingham.

Withers, Percy Malcolm, B.Sc., Senior Physics Master, Ricksmansworth Grammar School, Herts.

FELLOWSHIP of The Physical Society (11)

(a) Transferred from Student of the Institute and Society

Heap, Brian Richard, M.A., D.Phil., Junior Research Officer, Mathematics Division, National Physical Laboratory, Teddington, Middx.

Olive, Granville, B.Sc., Scientific Officer, Atomic Energy Research Establishment, Harwell, Didcot, Berks.

Whiting, Jeremy Simmonds Scott, M.A., D.Phil., Research Fellow, Clarendon Laboratory, Oxford.

(b) Other Elections

Conigan, Sydney James Burgess, B.Sc., D.Phil., Research Student, University College, London.

Cooper, Douglas Haslam, B.Sc., Research Assistant, U.K. Atomic Energy Authority, Windscale Works, Seascale, Cumb.

Entwistle, Noel James, B.Sc., Assistant Master, Rossall School, Cambs.

Eshelby, John Douglas, B.Sc., Ph.D., Lecturer, University of Birmingham.

Lanman, John Douglas, B.Sc., Senior Science Master, Seaford College, Petworth, Sussex.

Maddison, Richard Neville, B.A., B.Sc., Research Student/Assistant, Clarendon Laboratory, Oxford.

McInally, Michael, B.Sc., Ph.D., Senior Scientist, British Oxygen Company, London.

Partington, Frederick Roy, B.Sc., Research Student, University of Manchester.

Pears, Arthur, B.Sc., Senior Master, Handley Castle Grammar School, Worcester.

Senior, Harry Kenneth, B.Sc. ,Lecturer, Coventry Technical College.

Umezawa, Mindru, M.Sc., Ph.D., Attache, Institut de Recherches Nucleaires, Strasbourg, France.

Vaughan, Denys, M.Sc., Research Assistant, Imperial College of Science and Technology, London.

17 Students were also admitted.

Manuscripts accepted for publication in the Institute and Society's periodicals

British Journal of Applied Physics

Surface films on precious-metal contacts. By H. C. Angus.

A study of the incidence and behaviour of thin films on platinum–metal surfaces has been carried out by measuring contact resistance at loadings from 1mg to 5000mg. It is shown that reproducible results can be obtained, corresponding to film thicknesses of the order of 5Å. Surface properties appear to be more sensitive to the mode of preparation and the subsequent treatment than to the identity of the platinum metal. Abrasion leads to a progressive deterioration at light loads, whereas surfaces produced by breaking sintered compacts, by cold-forming, and by electrodeposition remain essentially stable over periods of months.

Rutherford Jubilee International Conference. By W. E. Burcham. A conference sponsored by the International Union of Pure and Applied Physics, the Royal Society, The Institute of Physics and The Physical Society, and the Victoria University of Manchester was held at Manchester between the 4th and 8th of September, 1961, in recognition of the jubilee of the discovery of the atomic nucleus by Rutherford. This arose directly from the experiments of Geiger and Marsden in Rutherford's laboratory at Manchester. Under the presidency of Sir Ernest Marsden a wide range of topics in experimental and theoretical nuclear physics was covered by a number of invited speakers. A special commemorative session was included in the proceedings.

Differential equations for the behavior of suspensoids. By G. Houghton.

By considering the diffusion of particles in a suspensoid as a Markoff process, it has been possible to obtain a flux vector for particle diffusion that is sufficiently general to be applicable to continuous phase flow in both the laminar and turbulent regimes. A uniform particle size distribution, this flux vector leads to a coupled pair of partial differential equations governing the formation and growth of the suspended phase. Through the use of ensemble averages these equations have been extended to the cases of non-uniform particle size distributions and have been coupled to similar equations describing heat transfer within the particles and heat and mass transport in the surrounding continuous phase. The equations provide a connection between the behaviour of single particles and the behaviour of a collection of particles, as well as taking into account the effects of nucleation, particle growth and coalescence in dilute suspensions.

Analysis of the stress–strain relationships in reactor grade graphite. By G. M. Jenkins.

Departures from linearity in the stress–strain relationships and plastic deformation are observed in reactor grade graphite at very small stresses. A model is put forward which describes the mechanical behaviour of such a material and a simple mathematical theory is derived which is shown to give an adequate description of the stress–strain relationships of graphite on stress cycling under low compressive stresses.

Surface wave technique for measuring the elastic properties and thickness of roads: theoretical development. By R. Jones.

The theoretical development of the experimental technique for measuring the elastic properties of the layers which make up a road is described. A knowledge of these properties is required in the development of a fundamental method of pavement design. The elastic properties are deduced from measurements of the wavelength and velocity of vibrations of known frequency along the surface of the road, and this paper develops the theory of the method of analysis of the relation between velocity and wavelength for single- and two-layer pavements.

Approximate theoretical solutions to the problem of an elastic square with rigid indenter. By D. W. Jordan and I. Evans.

A theoretical analysis is attempted of the ' indenter ' method of measuring the tensile strength of brittle materials, in which a flat square of the material is squeezed on opposite edges by a pair of symmetrically placed, rigid indenters. Four approximate solutions for elastic stresses in the square are obtained and compared with a photoelastic analysis which gave tensile stress at the centre as a function of the ratio of indenter width to side of square.

One solution is in good agreement with experiment. The inadequacy of the other three shows how careful it is necessary to be when approximating to boundary conditions, a consideration that applied equally to experiments with models.

Recovery of the insulating property of a vacuum gap after breakdown caused by a 4·5 μs pulse. By A. Maitland.

Following breakdown caused by a 4·5 μs pulse, a second 4·5 μs pulse of variable amplitude was used to investigate the recovery of the gap during the period from 5 μs–400 μs after breakdown. Recovery curves are presented for normal and overvolted breakdown. They show that the gap recovers at a rate ~10 kv/μs during the first 5 μs or so and ~0·01 kv/μs after about 100 μs. To explain the incomplete recovery after such long periods it is suggested that charged particles from the discharge channel reside on suitable insulating sites on the electrode surfaces and lead to discharge initiation when a sufficiently high field is next applied.

Role of oxidation in the mild wear of steel. By T. F. J. Quinn.

The structures of the wear debris obtained in several investigations into the mild wear of steel, i.e. the wear of relatively smooth steel surfaces, are compared with those to be expected from the results of representative oxidation experiments. It is assumed that sliding and stress have no effect on the oxides formed. Whilst this assumption is questionable on the grounds that surface conditions can have a large effect on certain features of oxidation, the comparison made on the basis of this assumption does in fact reveal a high correlation between the oxides actually obtained in the wear experiments and those to be expected from the oxidation data of Davies, Evans and Agar and Moreau and Bardolle, provided it is further assumed that oxidation occurs at the ' hot spot ' temperatures predicted from Archard's curves for single contact wear conditions. The tentative conclusions to be drawn from this correlation are examined in relation to the most probable method of oxide growth at a contacting asperity, and its removal to form a wear particle. A partly confirmed prediction regarding the variation of wear rate with speed is then made on the basis of these conclusions.

Observation accuracy in relation to the British Standards Institution draft recommendations for industrial instrument scale design. By J. Spencer.

The correct specification of industrial instrument observation error in terms of magnitude and frequency of error is discussed and experimental results are presented for two examples of scale design from the British Standards Institution draft recommendations. These results show that the design performance (95% of all observations shall have errors not exceeding $\pm 1\%$ of maximum scale value for a scale commencing at zero) is achieved providing that observers have a minimum of practice and are allowed a maximum of two seconds observation time under adequate illumination.

Principles governing the viscous flow of suspensoid sols. By T. V. Starkey, V. A. Hewlett, J. H. A. Roberts and R. E. James.

A theory relating to the viscous flow of stable suspensoid sols, and briefly outlined in earlier papers is extended in the present work.

It suggests (i) that concentration patterns are developed within suspensoid sols as a result of shearing, (ii) that these patterns arise through the operation of ' least action forces '. (The existence of such forces is required in order that the principle of least action shall be applicable to those changes in the configuration of the system of particles comprising the disperse phase of the sol which accompany shearing), (iii) that the velocity distribution pattern within such a sol is related in any given case to the concentration pattern, (iv) that the anomalous properties of suspensoid sols under shear arise in consequence of the development of these patterns and (v) that changes in these properties are due to changes in the parameters defining these patterns, and these, in turn to variations in the magnitudes of the least action forces with changes in the shearing conditions. It leads, in the case of flow through capillary tubes to the following conclusions:

(1) Shear dependence of viscosity is a universal characteristic of such sols. (2) The overall mean sol concentration within a tube during flow is always less than the concentration in the reservoir from which it is supplied. (3) The mean concentration over any cross-section diminishes systematically along a tube from a maximum value equal to the reservoir concentration (near to the entrance) to a minimum value at points nearer to the exit. (4) The overall mean sol concentration varies with flow rate from a maximum value (equal to the reservoir concentration) at zero rate of flow to a minimum value (always greater than one half of the reservoir concentration) at the highest rate for non-turbulent flow. (5) The velocity profile, as defined by the ratio of mean rate to maximum streaming velocity, is also shear dependent, the ratio varying systematically between limits of one half and one. (6) The ratios of mean to maximum velocity and of mean tube concentration to reservoir concentration are equal to one another for sols showing no appreciable Brownian movement and flowing in very long tubes. (7) These velocity and concentration ratios can under the conditions mentioned in (6), be expressed as a simple function of the relative viscosity of the sol. (8) The axial sol concentration increases systematically along the tube from a minimum value (equal to the reservoir concentration), near the tube entrance, to a maximum value which may be many times as great at points nearer to the exit. (This hyperconcentration will under appropriate conditions lead to the formation of a thrombus.)

Experiments designed for the investigation of the conclusions numbered (1), (2), (4), (5) and (7) are also described. The results yielded by these experiments support the conclusions mentioned.

In the light of these results Einstein's law which is based on the assumption of random particle distribution throughout a sol undergoing shear is seen to be fundamentally unsound.

Journal of Scientific Instruments

Direct method of measurement of losses in small samples of soft magnetic materials. By D. J. Harper.
An apparatus is described in which a simplified calorimetric method was used for the measurement of energy losses in small samples of soft magnetic materials subjected to alternating magnetization in the region of high flux densities and low audio frequencies. Measurements were made near the centres of single strip specimens used on open magnetic circuits. The method of measurement is without frequency or waveform limitations.

Constant pressure-differential gas apparatus for kinetic studies of gas–solid reactions. By J. C. Measor.
An apparatus which includes essentially a Rotameter for the measurement of small rates of flow of gas, is designed to enable instantaneous reaction rates of gas–solid reactions to be obtained continuously.

Note on search coil errors in the measurement of axial magnetic fields. By A. Pearson.
An expression is derived for magnetic fields with axial symmetry relating the actual value of the flux density at a point on the axis to the flux density measured by a search coil. It is shown that the error due to the search coil depends upon the even order derivatives of the actual flux distribution, and in some cases may be eliminated by careful design of the coil.

Apparatus for the controlled orientation of crystallographic specimens for ultra-thin sectioning. By R. Phillips and J. H. Lucas.
A specimen holder is described which allows the specimen to be rotated through 360° about its own axis of symmetry. This adjustment is provided both before and after two curved slides whose axes of curvature are mutually orthogonal and orthogonal to the 360° rotation axis. Each curved slide allows a variation in orientation of the specimen of ±15°. This specimen holder can be fitted to the Leitz Ultramicrotome with only slight modifications to the advance arm and the removal of a small amount of material from the binocular mounting and main casting. The development of an x-ray Laue back to reflection camera to enable the orientable holder to be employed to orient given crystallographic planes into the plane of cutting is described.

Storage oscilloscope used in conjunction with the scanning electron probe microanalyser. By G. V. T. Ranzetta andV. D. Scott.
The value of a Remscope storage oscilloscope as an accessory to a Cambridge scanning microanalyser is assessed using widely different test specimens. It is concluded that although the storage tube does not replace the existing method for obtaining x-ray pictures suitable for reproduction purpose, it is nevertheless a useful aid for judging the desired photographic exposure times and the appropriate magnification for a particular field of view. The most important facility the device offers is considered to be that for positioning the electron probe with direct reference to the x-ray image thereby allowing point analysis of a particular microstructural feature to be carried out with a greater consistency than was previously possible.

Method for obtaining minimum noise in a general purpose hot wire amplifier. By G. N. V. Rao.
It has been shown that the conventional practice of designing a compensated hot wire amplifier with a fixed ceiling to floor ratio results in considerable and unnecessary increase in noise level at compensation settings other than optimum (which is at the maximum compensation at the highest frequency of interest). The optimum ceiling to floor ratio has been estimated to be between $1{\cdot}5$–$2{\cdot}0$ α_{max} M. Application of the above considerations to an amplifier in which the c/F ratio is optimized at each compensation setting (for a given amplifier bandwidth), shows the usefulness of the method, in improving the signal to noise ratio.

Proceedings of The Physical Society

The equivalent two-body method for the hypertriton. By Leila Abou-Hadid and K. Higgins.
The equivalent two-body method proposed by Feshbach and Rubinow in 1955 has been applied to the calculation of the triplet of Λ-nucleon interaction necessary to explain the observed binding energy of the hypertriton. An appreciably smaller value of the volume integral is required than when a final function of comparable simplicity is employed in the usual variation method. The effect of introducing a term in the potential representing a three-body Λ-nucleon–nucleon interaction is investigated.

An investigation of the ^{28}Si(p, γ)^{29}P reaction. By E. E. Baart, L. L. Green and J. C. Willmott.
The ^{28}Si(p, γ)^{29}Si reaction has been studied at six resonances below 1 mev. From analysis of the results obtained spin and parity assignments have been made to six of the low-lying levels, and tentative assignments to four more levels.
It is shown that these results do not readily fit in with what is expected on the Nilsson model.

Paramagnetic resonance of a Cu^{2+} ion in a tetrahedral crystal field. By C. A. Bates, W. S. Moore, K.J. Standley and K. W. H. Stevens.
Paramagnetic resonance has been observed in the unstable organic complex Cu^{2+} (αα′ bromo-) dipyromethene, where the Cu^{2+} ion is thought to reside in an approximately tetrahedral crystal field. The resulting spectrum shows no resolved hyperfine structure from the copper nuclear spin of 3/2, the line-width setting an upper limit of 20 Oe for the splitting. Insertion of the measured g-values into the existing formulae, however, predicts a value of approximately 200 Oe. A theoretical study of a Cu^{2+} ion shows that, in a tetrahedral field, small admixtures of $4p_z$ wave functions with the 3dxy ground state are possible, leading to a greatly reduced hyperfine splitting. This effect is given a physical interpretation and these results are shown to be consistent with crystal field calculations. The contact parameter is estimated to be $-1{\cdot}4$ atomic units compared with the value of $-3{\cdot}0$ atomic units usually obtained.

Existence of energy gaps in one-dimensional liquids. By R. E. Borland.
It is shown that a definite energy gap exists in a one-dimensional liquid provided that the maximum deviation of the distance between atoms is less than a critical value. Higher gaps successively appear as the disorder is further reduced.

The effect of a thermal gradient upon charge separation between similar polyethylene surfaces. By A. H. Bowles.
The apparatus and method are described by which the separation of electrostatic charge between similar polyethylene spheres, initially at different temperatures, during an impulsive contact has been observed.
The amount of such a charge separation varies progressively and randomly during a series of observations. A component of this charge separation is shown to depend upon the direction of the thermal gradient across the interface. A progressive variation in charge separation with number of impacts is observed which may be due to a transfer of 'active centres' from one surface to the other. The quantity of charge which separates between two surfaces is also shown to vary with different contact areas on one surface.

The isomer shift in ^{119}Sn and the quadrupole moment of the first excited state. By A. J. F. Boyle, D. St. P. Bunbury and C. Edwards.
By means of the Mössbauer effect, the nuclear quadrupole splitting of the first excited state of ^{119}Sn has been measured in several tin compounds and a comparison made of the isomer shifts of the ground state transition. The isomer shift is interpreted in terms of a change in the mean square deformation of the nucleus $\langle\beta^2\rangle$ arising mainly from the zero point vibrational motion. The difference in $\langle\beta^2\rangle$ between the excited and ground states is found to be $\sim 6 \times 10^{-4}$. From estimates of the field gradient at the ^{119}Sn nucleus a value of approximately -8×10^{-24} cm^2 has been assigned to the quadrupole moment of the 3/2$^+$ state. Values of the two measured quantities are calculated using a model of a single particle coupled to a vibrator. The inclusion of pairing correlations of the nuclear force is necessary to obtain agreement with the experimental results.

The scintillation phenomenon in anthracene. I Radiation damage. By H. B. Clarke, D. C. Northrop and O. Simpson.
The effects of radiation damage on the scintillation efficiency of anthracene crystals are shown to be comparatively small. They cannot account for the low efficiency observed for particles of high specific ionization, even where the integrated effects of prolonged irradiation are very marked. Some evidence is found for a reduction in scintillation efficiency in impure anthracene, where emission occurs only from impurity centres, but this is a co-operative effect between excited states, and is not connected with permanent radiation damage.

The theory of the Faraday effect in anisotropic semiconductors. By B. Donovan and Janet Webster.
A formal treatment of the Faraday effect, due to free charge carriers, is developed for arbitrary directions of propagation in anisotropic semiconductors. General expressions for the Faraday rotation and the ellipticity are derived, in terms of four quantities which involve components of the tensors representing the dielectric constant and the high frequency conductivity in the presence of a magnetic field.
It is found that, in contrast to the isotropic case, both the rotation and ellipticity depend upon both the real and imaginary parts of the complex propagation constants. An examination is also made of the two elliptically polarized component waves into which the initially plane polarized radiation is resolved. Two special cases are discussed, of particular relevance to crystals with cubic symmetry, in which a simplification of the general expressions may be effected.

The gamma radiation from ^{212}Po(ThC′). By F. C. Flack and J. E. Johnson.
The decay of ThC (^{212}Bi) to ThC′ (^{212}Po) has been studied by coincidence techniques and those gamma radiations emitted from the ^{212}Po nucleus have been distinguished from other gamma rays in the thorium decay series. An estimate of intensities has enabled some spin and parity assignments to be made to the excited levels. The branching ratio of ^{212}Bi and the half-life of the ground state of ^{212}Po were remeasured.

The scintillation phenomenon in anthracene. II Scintillation pulse shape. By P. E. Gibbons, D. C. Northrop and O. Simpson.
Detailed examination of the scintillation pulse shape in anthracene leads to the hypothesis that the slow components (∼1μsec decay time) are due to short range interactions between pairs of excitons. These components are observed in the fluorescence decay due to pulsed ultra-violet excitation when the intensity is increased to produce an exciton density approaching that near the track of an ionizing particle. A number of deductions concerning the scintillation pulse shape in impure anthracene are borne out by experiment.

Neutron diffusion in small volumes of water: pulsed source measurements. By R. S. Hall, S. A. Scott and J. Walker.
The thermal neutron diffusion parameters for light water have been measured using the pulsed neutron source technique. It has been demonstrated that the value of the diffusion cooling coefficient is critically dependent on the physical shape of the experimental system. The experimental results have been analysed using two different values of the extrapolation length, since the value of this parameter is not accurately known. The discrepancies between previously published values of the diffusion parameters are largely explained by their dependence on system shape and extrapolation length.

Stability of longitudinal electrostatic oscillations in plasmas of finite dimensions. By E. R. Harrison.
This paper discusses the stability of longitudinal electrostatic oscillations in plasmas of finite dimensions. It is shown that in general the effect of simple boundary conditions is to increase the domain of stability. Thus, a cylindrical plasma of radius a consisting of electron and ion streams of equal temperatures and surrounded by a coaxial conducting boundary of radius b, where $b \geqslant a$, is stable for all stream velocities when $\lambda_D > 0{\cdot}53\, a \times [\ln(b/a)]^{1/2}$, where λ_D is the Debye length. In the case of a plane-shaped plasma of semi-width a, between parallel plane conducting boundaries at distance b, the equivalent condition is $\lambda_D > \{2(ab-a^2)\}^{1/2}$. More generally, for multi-stream plasmas, in which the component streams have arbitrary temperatures and densities, it is possible to give a sufficient condition of stability for all stream velocities. The stability of three stream plasmas is briefly discussed, and it is shown that the experimental results of Looney and Brown, and their failure to observe any excitation of plasma oscillations, are in accord with the stability criteria for plasmas of finite dimensions. Attention is drawn to the similarity between plane-shaped plasmas and auroral arcs, and also the similarity between cylindrical-shaped plasmas and auroral rays. It is suggested that the difference of the stability conditions for plane and cylindrical-shaped plasmas may account for the tendency of auroral arcs to disrupt into rayed structures.

Optical model analysis of the elastic scattering of low energy deuterons. By R. N. Maddison.
Experimental cross sections of the elastic scattering of 1 to 20 mev deuterons by various nuclei have been analysed using the optical model without spin–orbit forces. Two methods of predicting parameter values have been studied; the least squares method, with some modifications, has found more satisfactory. In most cases it is possible to obtain satisfactory agreement between theory and experiment, and trends in the parameters are shown.

C. V. BOYS LECTURE

Counter techniques in high energy nuclear physics: rare decays of π^+ and μ-mesons. By A. W. Merrison.
It is shown, with particular reference to the decay $\mu^+ \to e^+ + \gamma$, how the study of rare decays of pions and muons, by means of counter techniques, has contributed to our understanding of the weak interactions.

The pressure dependence of the second ionization coefficient in hydrogen at low pressures. By J. G. C. Milne.
Experiments on sparking potentials in hydrogen at low pressures (10–100 mm Hg) have shown that the sparking potential is not just a function of the product of gas pressure and sparking distance (Paschen's Law), but decreases as the gas pressure is decreased. Values of the generalized secondary coefficient deduced from these results therefore show a pressure dependence which is approximately linear. The loss of excited molecules by collisions of the second kind proposed by Davies, Dutton and Llewellyn Jones seems inadequate to account quantitatively for these results. The loss of excited molecules by collision with the anode is suggested as an additional mechanism.

Indirect magnetic exchange interactions in α-Fe_2O_3 and Cr_2O_3. By W. P. Osmond.
It is shown that the different antiferromagnetic arrangements of ordered magnetic spins in the identical lattices of α-Fe_2O_3 and Cr_2O_3 can be explained by the overlap of suitably directed oxygen p orbitals and the differently populated d orbitals of the Fe^{3+} and Cr^{3+} ions.

The electronic structure and spectrum of benzonitrile. By T. E. Peacock and P. T. Wilkinson.
The electronic structure and spectrum of benzonitrile have been calculated using SCF MO theory. The two Π electron systems are considered to be non-interacting.
The first five bands of the electronic spectrum are interpreted in terms of the low-lying singlet and triplet states. All of these bands are benzene analogues.

The formation and implosion of a current sheet in a gas discharge containing reversed magnetic fields. By N. J. Phillips.
A theory is developed of the formation and implosion of a gas discharge in reversed axial magnetic fields. When a discharge is formed in neutral gas containing a trapped field of opposite sense to the applied field, the formation and implosion of the discharge are profoundly influenced. A simple theory of the formation of a reversed field sheath in neutral gas is given and it is shown that the sheath thickness is proportional to the plasma wavelength $(m_e c^2/4\pi n_e e^2)^{1/2}$ and weakly dependent on the ratio of scattering to ionization rates. On the basis of Buneman's theory of electrostatic instability of electron streams, it is suggested that ionization growth rates are limited by the onset of electrostatic instability when the electron temperature in the sheath exceeds a certain value (≈ 50ev) determined by the high energy behaviour of the scattering and ionization rates. The implosion of the discharge can be appreciably affected by the finite resistivity of the plasma and a simple model of the implosion of a resistive reversed field pinch is discussed. Due to field annihilation during the implosion, and the effect of wall bang up, implosions may be considerably faster than those achieved under like field conditions. It is shown that a critical magnitude of the initial reversed field exists above which it is amplified reversed and below which it passes through zero and is amplified with the same sense as the external field.

The complex band system of MnF in the near ultra-violet. By S. V. Krishna Rao, S. Paddi Reddy and P. Tiruvengana Rao.
The complex band spectrum of MnF in the near ultra-violet has been photographed under high dispersion. A new analysis of the observed heads has been made, but the transition, in agreement with the earlier work of Bacher, is still interpreted as $^7\Pi \rightarrow {}^7\Sigma$.

Correction of spectroscopic line profiles for instrumental broadening by a Fourier analysis method. By J. S. Rollett and L. A. Higgs.
The large uncertainties inherent in correction methods using linear equations are expressed in terms of the behaviour of the Fourier transforms of the observed profile and the apparatus function. The Fourier transform method is described in a form which provides a systematic allowance for the effects of experimental errors, so that the process can be conveniently programmed for a computer.

Electron-phonon interaction by the method of pseudo-potentials. By L. J. Sham.
The matrix element is calculated (i) for orthogonalized plane waves assuming that the ion moves rigidly, and (ii) for the equivalent plane waves on the assumption that the net effective potential (Hartree–Fock potential plus pseudo-potential) moves rigidly with the ion. It is shown that these two results are equivalent if the pseudo-potential operator can be treated as a localized potential.

Magnetic studies on potassium permanganate. By O. P. Singhal.
The principal magnetic susceptibilities of single crystals of potassium permanganate have been measured from room temperature down to liquid oxygen temperature. The results on magnetic anisotropy have been discussed in relation to the fine structure studies of the crystal by x-ray methods. The feeble paramagnetism of the crystal has been attributed to the high frequency paramagnetism of Van Vleck. This paramagnetism has been found to vary slightly with temperature.

On the exactness of the spin-Hamiltonian description of Fe^{3+} in sapphire. By H. F. Symmons and G. S. Bogle.
The spin-Hamiltonian coefficients for Fe^{3+} in sapphire have been redetermined by the classical paramagnetic resonance method. The value of g is $2{\cdot}0026 \pm 0{\cdot}0005$ and is independent of temperature. The a coefficients, in units of 10^{-4} cm^{-1}, and for temperatures of 4 °K, 80 °K and 299 °K respectively, are: $D = -1719{\cdot}2$, $1718{\cdot}2$, $1678{\cdot}5$; $a = -229{\cdot}4$, $236{\cdot}4$, $229{\cdot}1$; $F = -112{\cdot}1$, $101{\cdot}3$, $100{\cdot}8$; (D and a ±1 unit; F ±2 unit). The paramagnetic resonance lines are consistent with the spin-Hamiltonian to within the experimental error of 2 gauss. The zero-field splitting frequencies, measured directly, are, for 4 °K, 80 °K and 299 °K respectively: $\nu(5/2, 3/2) = 19\,281$, $19\,288$, $18\,856$; $\nu(3/2, 1/2) = 12\,037$, $12\,029$, $11\,741$ Mc/s (all $\pm 0{\cdot}05$%). These frequencies are consistent with the spin-Hamiltonian using the above coefficients. It is concluded that the spin-Hamiltonian is valid within the above limits of error for fields from zero to 10 000 gauss.

Electron spin resonance in neutron-irradiated polycrystalline beryllium oxide. By G. J. Troup and J. R. W. Thyer.
Electron spin resonance, presumably from electrons or holes bound to appropriate vacancies, has been detected in neutron-irradiated polycrystalline BeO. A preliminary study of the behaviour of the intensity and line-shape of the electron spin resonance signal with increasing radiation dose, and on annealing, has been made. Considered as an anisotropic line, the electron spin resonance signal prior to annealing has the following g-values (approximate only):

$$g_{\parallel} = 2{\cdot}0036 \pm 0{\cdot}001$$
$$g_{\perp} = 2{\cdot}0110 \pm 0{\cdot}001$$

However, the change of line-shape of the electron spin resonance signal after annealing tends to indicate that the initial signal may come from more than one type of spin centre.

The diffusion of zinc and cadmium in indium antimonide. By R. B. Wilson and E. L. Heasell.
The diffusion of zinc and cadmium into selenium-doped InSb has been studied. The results obtained indicate the importance of out-diffusion and the presence of surface rate limitation. Estimates are made for the diffusion constants of the two materials.

LETTERS TO THE EDITOR

Cyclotron resonance at 4 mm wavelength. By D. M. S. Bagguley and R. A. Stradling.

Distortion approximation to cross sections for excitation of 1s–1p transition of hydrogenic ions by bare nuclei. By D. R. Bates.

New bands in the second negative system of oxygen. By J. Byrne.

Anisotropy in the electric strength of alkali halide crystals. By R. Cooper and A. Fernandez.

Excess high-frequency noise in junction transistors. By F. J. Hyde, H. J. Roberts and B. E. Buckingham.

On the Θ values from the temperature dependence of the Laue-Bragg scattering. By S. K. Joshi.

THE ROYAL COLLEGE OF ADVANCED TECHNOLOGY, SALFORD

DEPARTMENT OF PURE AND APPLIED PHYSICS

Applications are invited for various posts at all levels in the above department. Suitably qualified persons interested in the work of a department which is concerned with Sandwich courses for the Diploma in Technology, courses for B.Sc.Special of London University and courses in Nuclear Power Technology, and where the development of research is encouraged, are invited to send in full particulars (quoting reference PH) to the Registrar, Royal College of Advanced Technology, Salford 5, Lancs., as soon as possible.

UNIVERSITY OF NATAL DEPARTMENT OF MATHEMATICS AND APPLIED MATHEMATICS

Applications are invited from suitably qualified persons for appointment to two posts of LECTURER IN MATHEMATICS AND APPLIED MATHEMATICS, DURBAN. The salary scale attached to the posts is R2,340 × 120–R3,300 (£1,170 × £60–£1,650) per annum. The commencing notch on the above salary scale will be dependent on the qualifications and/or experience of the successful candidate. Application forms and further particulars of the posts, including commencing dates, etc., are obtainable from the Secretary, Association of Universities of the British Commonwealth (Branch Office), Marlborough House, Pall Mall, London, S.W.1. Applications close in South Africa and London on November 30, 1961.

BUILDING RESEARCH STATION (D.S.I.R.), Garston, Nr. Watford, Herts., requires Scientific Officer, physicist or physical chemist, for a fundamental study of the processes of abrasion of non-metallic materials. The investigation is part of a larger study of flooring materials and will be conducted in parallel with field studies of wear and the development of abrasion-testing machines. Qualifications: 1st or 2nd class honours degree in Physics or Chemistry or equivalent. Interim salary range £717–£1,222. Forms from Director, above address, quoting BRS 39ZY. Closing date November 29, 1961.

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A course of ten lectures on " Dislocation Theory ", to be held on Thursdays, at 6.30 p.m., commencing January 11, 1962. The course is suitable for graduates in Physics, Metallurgy, Mathematics and Chemistry. Fee £1 0s. 0d. Enrolment forms and further details may be obtained from the Secretary (Dislocation Theory Course), Battersea College of Technology, London, S.W.11.

The Institute and Society is arranging a Symposium on

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Enquiries regarding the program should be addressed to the Organizing Secretary, Mr. M. L. Owens, Central Electricity Generating Board, Friars House, 157-188 Blackfriars Road, London, S.E.1.

Some residential accommodation will be available. Further details and application forms will be obtainable early in the New Year from the Administration Assistant of the Institute and Society.

The Institute and Society is arranging a one day Symposium on

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PRINTED BY F. J. MILNER AND SONS LIMITED, BRENTFORD AND LONDON.

A PHYSICS ANTHOLOGY

EDITED BY

NORMAN CLARKE

Deputy Secretary, The Institute of Physics and The Physical Society

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